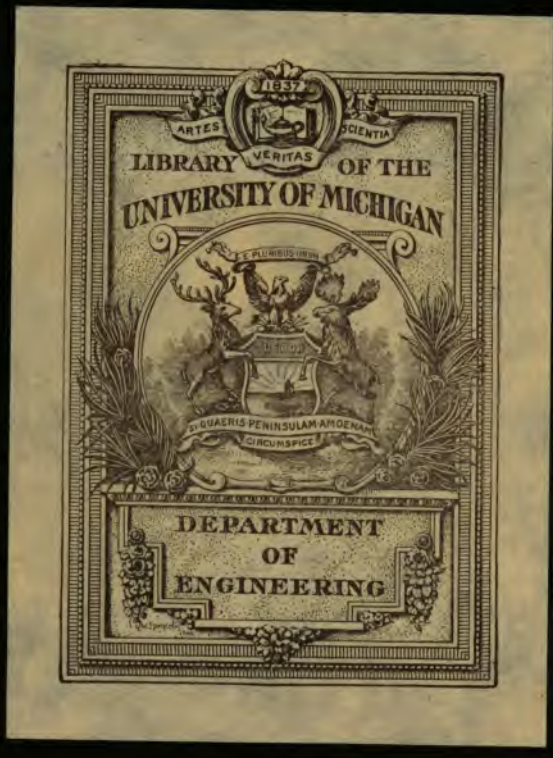
# APPLEBY'S HANDBOOK OF MACHINERY.

## SECTION I.

## PRIME MOVERS.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# APPLEBY'S
# ILLUSTRATED HANDBOOK
OF
# MACHINERY.

## SECTION I.—PRIME MOVERS,

INCLUDING

FIXED, PORTABLE AND MARINE ENGINES,
BOILERS AND FITTINGS, WATER HEATERS AND ACCESSORIES,
GAS, OIL AND HEATED AIR ENGINES,
DYNAMOS AND ELECTRIC MOTORS,
TURBINES,
WATER WHEELS, WIND ENGINES AND HORSE POWER GEARS,

WITH

*PRICES, WEIGHTS, MEASUREMENTS, AND SOME DATA ON WORKING EXPENSES AND RESULTS OBTAINED.*

BY

**C. J. APPLEBY, M. Inst. C.E.,**

(JESSOP & APPLEBY BROS., LEICESTER & LONDON, LIMITED.)

**22, WALBROOK, LONDON, E.C.**

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# APPLEBY'S HANDBOOK OF MACHINERY

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The Edition published in 1869, and several reprints of it having been exhausted, a New Edition (of which this section forms a portion) is now being completed; and for the convenience of those who desire information on specific subjects, but not on all those treated, the book will be divided into seven sections, each of which may be obtained separately as follows :—

SECTION 1.—**PRIME MOVERS.**

STEAM, GAS AND AIR ENGINES, BOILERS, TURBINES, ETC.

SECTION 2.—**HOISTING MACHINERY.**

WINDING ENGINES, HYDRAULIC, STEAM, ELECTRICAL AND HAND CRANES, WINCHES, JACKS AND OTHER LIFTING APPLIANCES.

SECTION 3.—**PUMPING MACHINERY.**

PUMPING ENGINES, CENTRIFUGAL, STEAM, ELECTRICAL AND HAND PUMPS.

SECTION 4.—**MACHINE TOOLS**
AND ACCESSORIES.
FOR WORKING METALS, WOOD, ETC.

SECTION 5.—**CONTRACTORS' PLANT AND RAILWAY MATERIALS,**

INCLUDING MACHINERY AND MATERIALS FOR THE CONSTRUCTION AND EQUIPMENT OF RAILWAYS AND OTHER PUBLIC WORKS.

SECTION 6.—**MINING, COLONIAL AND MANUFACTURING MACHINERY.**

FOR TREATING ORES, CORN, COFFEE, RICE, SUGAR, COTTON, AND OTHER PRODUCTS, OIL MILLS, ICE MAKING, DISTILLING, ETC.

SECTION 7.—**USEFUL TABLES AND MEMORANDA.**

FOR ENGINEERS, MERCHANTS, AND MANUFACTURERS.

**Each Section, bound in cloth, is sold separately, price 3/6 each.**

The subject matter has been entirely re-written, and is illustrated by a large number of Engravings which (for the most part) represent work carried out by the Author's Firm.

The arrangement is intended to be in a handy form for reference, useful alike to engineers, users, and to purchasers of machinery and of materials connected therewith.

The prices are based on the present cost of materials and of labour and these—as well as details of design and proportions—are necessarily subject to modification without notice.

Some data is given with reference to the cost of working, motive power required and work performed; also approximate weights and measurements, so that the results obtainable and the total cost including freight, import duties, &c., may be roughly estimated. The cost of packing for shipment and delivery to docks varies with the nature of the packing required and the destination, the rates given being the average as nearly as they can be determined.

Code Words for each kind of machine will be found in the index, and these, in conjunction with the sentence words in Appleby's Copyright Telegraph Code which precedes the Index, will usually suffice for correspondence by cable; by specifying the listed price in figures the leading dimensions of the tool required can be indicated.

# PREFACE.

Much information relating to the matters referred to in the following pages will be found in text books, treatises, and trade catalogues, but it is treated, for the most part, in a manner too technical to be of real service to many who—although buyers and users of machinery—may not possess intimate knowledge of details of construction, the cost of machines, their productive capacity, &c.

Conscious, as the Writer is, that the efforts of no single individual will suffice to cover the ground thus left vacant, he has attempted to cover some of it by presenting information with regard to the construction, the approximate prices of the machines described, the probable output, and other data which will serve as a basis for estimating the cost of the machinery and, approximately, the cost of working it.

The arrangement adopted in the first edition of APPLEBY'S HANDBOOK OF MACHINERY, which was published in 1869, has been to a large extent adhered to in this edition, but the advances made in all branches of mechanical construction since that time, have been so incredibly great and varied, that nothing which appeared in the above-named edition, or the numerous reprints of it, have been found suitable for reproduction, so that the descriptive matter has been entirely re-written and—as far as practicable—corrected up to this date.

It is to be regretted that lack of space precludes a more extended notice of some (and causes the complete omission of other) interesting inventions and improvements in special departments of engineering design and the selection of subjects is necessarily limited to those which may be regarded as being of general interest.

*London,*
*1st January, 1896.*

# APPLEBY'S COPYRIGHT TELEGRAPHIC CODE

## FOR CORRESPONDENCE BY TELEGRAM.

NOTE.—CABLE ADDRESS: "MILLWRIGHT, LONDON."

## ENQUIRIES AND QUESTIONS.

| | | |
|---|---|---|
| 191290 | **Taaier** | ..Telegraph how soon you could ship the following, viz..... |
| 191291 | **Taaiheid** | ..Reply, by letter, how soon you could ship the following, viz..... |
| 121292 | **Taainagel** | Telegraph at what price, packed and delivered f.o.b. English port, you could supply and ship the following, viz..... |
| 191293 | **Taalboek** | Reply, by letter, at what price, packed and delivered f.o.b. English port, you could supply and ship the following, viz..... |
| 191294 | **Taaldeel** | Telegraph how soon and at what price, packed and delivered f.o.b., you could supply and ship the following, viz..... |
| 191295 | **Taaleigen** | Reply, by letter, how soon and at what price, packed and delivered f.o.b. English port, you could supply and ship the following, viz. ..... |
| 191296 | **Taalfout** | ..Telegraph name of vessel by which you have shipped. |
| 191297 | **Taalgebrek** | We learn that the.....with your goods on board has been lost. Shall we replace? |
| 191298 | **Taalgids** | ..Telegraph, at my expense, how soon my order will be despatched. |
| 191299 | **Taalgrond** | ..Reply, by letter, how soon my order will be despatched. |
| 191300 | **Taalkundig** | ..Do you wish us to proceed with order? |
| 191301 | **Taalman** | ..Will you leave matter to our discretion? |
| 191302 | **Taalregel** | ..When will remittance be sent for £..... |
| 191303 | **Taalschat** | ..Send us a complete tracing of..... |
| 191304 | **Taalteeken** | ..Send us a photograph of..... |
| 191305 | **Taalvitter** | ..Send us a complete estimate for the following..... |
| 191306 | **Taalvriend** | Prepare design and send tracing and estimate including delivery f.o.b. for..... |
| 191307 | **Taalwet** | ..Can you alter the goods to our order as follows..... |
| 191308 | **Taalzifter** | ..How soon can you deliver? |
| 191309 | **Taanbloem** | ..Have you in stock? |
| 191310 | **Taartblik** | ..A reply by wire is requested. |
| 191311 | **Taarten** | ..A reply by first mail is requested. |

## ORDERS AND INSTRUCTIONS

| By Sailing Vessel. | Steamer. | Mail Boat. | |
|---|---|---|---|
| 191312 **Taartepan** | 191313 **Taartjes** | 191314 **Taartkoek** | Please supply and ship as soon as possible the following goods, engaging freight and insurance free of particular average. |
| 191315 **Tababocca** | 191316 **Tabacalero** | 191317 **Tabacales** | Please supply and ship as soon as possible the following goods, engaging freight and insurance, free of all risks, if latter is possible. |

| | | | |
|---|---|---|---|
| 191318 | **Tabaccasse** | ..No part of the machine must weigh more than.....cwts. | |
| 191319 | **Tabacchi** | ..We leave matter to your discretion. | |
| 191320 | **Tabacomane** | ..Preferring them in the order named. | |
| 191321 | **Tabacosas** | ..Payments will be made by..... | |
| 191322 | **Tabacoso** | ..Payments will be made by..... | Arrange terms with that firm. |
| 191323 | **Tabagie** | ..Terms will be as before. | |
| 191324 | **Tabagique** | ..Remittance is delayed until..... | |
| 191325 | **Tabahia** | ..Draw on us at sight for £..... | |
| 191326 | **Tabakasche** | ..Draw on us at..... | |
| 191327 | **Tabakbau** | ..Await instructions for shipment. | |
| 191328 | **Tabakbeize** | ..Replace with all possible despatch. | |
| 191329 | **Tabakdampf** | ..Duplicate our order of..... | |
| 191330 | **Tabakkorb** | ..Repeat our order for..... | |
| 191331 | **Tabakladen** | ..Repeat our last order. | |
| 191332 | **Tabakqualm** | ..Await our letters before proceeding. | |

## Orders and Instructions — *Continued.*

| | | |
|---|---|---|
| 191333 | **Tabakrauch** | ..Same pattern or quality as before. |
| 191334 | **Tabakreibe** | ..The same as you last supplied. |
| 191335 | **Tabakrolle** | ..Same as supplied by you in..... |
| 191336 | **Tabaksblad** | ..Same as supplied by.....in..... |
| 191337 | **Tabaksbouw** | ..Same as supplied to.....in..... |
| 191338 | **Tabaksland** | ..Draw on us for £..... at the following number of days from sight. |
| 191339 | **Tabakspijp** | ..Please deliver at once. |
| 191340 | **Tabaksrook** | ..Please deliver next week. |
| 191341 | **Tabakstube** | ..Must be inspected by..... |
| 191342 | **Tabaksvat** | ..Ship at once. |
| 191343 | **Tabaksveld** | .....has been irreparably damaged send another. |
| 191344 | **Tabakszak** | .....has been lost replace it immediately. |
| 191345 | **Tabaleabau** | ..Please send by next mail certificate for..... |
| 191346 | **Tabaleara** | ..Prepare for delivery at once. |
| 191347 | **Tabaleos** | ..Wanted for immediate delivery. |
| 191348 | **Tabalhiom** | ..The makers were (are)..... |
| 191349 | **Tabalhiado** | ..As described in Appleby's Handbook of Machinery, price £..... |

## ANSWERS. &c.

| | | |
|---|---|---|
| 191350 | **Tabanca** | ..Freight will add about.....per cent. to the f.o.b. cost. |
| 191351 | **Tabanidae** | ..The machine will weigh about.....cwts. |
| 191352 | **Tabaquear** | ..The total weight will be about.....tons. |
| 191353 | **Tabaqueiro** | ..The total measurement will be about.....cubic feet. |
| 191354 | **Tabaqueras** | ..No part of the machine will weigh more than.....cwts |
| 191355 | **Tabaqueurs** | ..The machine is finished. |
| 191356 | **Tabaquista** | We can supply you with goods, as per your enquiry, at the following *net* price. |
| 191357 | **Tabardelha** | ..Please telegraph credit with some English Bank for order just received. |
| 191358 | **Tabarder** | The credit opened with the Bank is too small; please to Telegraph further credit for £..... |
| 191359 | **Tabardilho** | ..We cannot execute order on other terms. |
| 191360 | **Tabarzet** | ..We have remitted you by letter £..... |
| 191361 | **Tabatiere** | ..Cash will be paid against Bill of Lading by..... |
| 191362 | **Tabaxir** | ..Machinery is shipped by steamer. |
| 191363 | **Tabbaard** | ..Machinery will be shipped by steamer. |
| 191364 | **Tabbaoth** | ..Machinery is shipped by sailing vessel. |
| 191365 | **Tabbinet** | ..Machinery will be shipped by sailing vessel. |
| 191366 | **Tabbying** | ..Your order received and has our best attention. |
| 191367 | **Tabebuia** | ..Remittance follows by mail. |
| 191368 | **Tabefatto** | ..Remittance will be sent immediately for £..... |
| 191369 | **Tabefied** | ..Waiting your remittance |
| 191370 | **Tabellaria** | ..Credit arranged through. |
| 191371 | **Tabellaron** | ..Credit arranged by telegraph |
| 191372 | **Tabelle** | ..£10 additional needed to cover cost. |
| 191373 | **Tabelliar** | ..£20 ,, ,, ,, |
| 191374 | **Tabellioa** | ..£30 ,, ,, ,, |
| 191375 | **Tabellions** | ..£40 ,, ,, ,, |
| 191376 | **Tabellone** | ..£50 ,, ,, ,, |
| 191377 | **Taberd** | ..£60 ,, ,, ,, |
| 191378 | **Tabergite** | ..£80 ,, ,, ,, |
| 191379 | **Tabernacle** | ..£100 ,, ,, ,, |
| 191380 | **Tabernero** | ..£ ,, ,, ,, |
| 191381 | **Tabescence** | ..We can deliver from stock. |
| 191382 | **Tabescent** | .. ,, ,, in one week. |
| 191383 | **Tabetique** | .. ,, ,, in two weeks. |
| 191384 | **Tabicadas** | .. ,, ,, in three weeks. |
| 191385 | **Tabicamos** | .. ,, ,, in four weeks. |
| 191386 | **Tabicar** | .. ,, ,, in six weeks. |
| 191387 | **Tabicaron** | ..The time for delivery should be.....weeks. |
| 191388 | **Tabicones** | ..The time of delivery is of great importance. |
| 191389 | **Tabido** | ..All charges will be accounted for..... |
| 191390 | **Tabificas** | ..All charges will be paid by..... |
| 191391 | **Tabiflui** | ..I (we) cannot promise delivery until..... |
| 191392 | **Tabifluos** | ...I (we) cannot promise delivery in the time stated, letter follows. |

## Answers, &c.—*Continued.*

| | | |
|---|---|---|
| 191393 | **Tabiosis** .. | I (we) cannot promise delivery in time stipulated, please telegraph instructions. |
| 191394 | **Tabique** .. | ..We have not received yours of the..... |
| 191395 | **Tabiqueis** .. | ..Replying to your telegram, (enquiry) our price is £..... |
| 191396 | **Tabiquemos** | Replying to your telegram, our price, subject to prompt confirmation of order, will be £..... |
| 191397 | **Tabiser** .. | ..Full information follows by mail. |
| 191398 | **Tablaeho** .. | ..Tracing and estimate will be sent. |
| 191399 | **Tablabo** .. | ..Tracing and estimate were sent. |
| 191400 | **Tablajero** .. | ..We have received your order for..... |

## GENERAL MESSAGES.

| | | |
|---|---|---|
| 191401 | **Tablares** .. | .....steamer is delayed by having to put in at..... |
| 191402 | **Tablazones** | .....is erected and works satisfactorily. |
| 191403 | **Tablazos** .. | .....is erected but does not work satisfactorily. |
| 191404 | **Tableabais** .. | .....is erected but does not yet work satisfactorily, send immediately by quickest route. |
| 191405 | **Tableadas** .. | .....will leave on or about the..... |
| 191406 | **Tablearia** .. | .....cannot leave before the..... |
| 191407 | **Tablearon** .. | .....is completed. |
| 191408 | **Tableaux** .. | ..I (we) will see you on or about..... |
| 191409 | **Tableros** .. | ..We must have dimensions, sketches, or drawings. |
| 191410 | **Tabliers** .. | ..We require more detailed information with reference to..... |
| 191411 | **Tablilha** .. | ..We are sending you additional information with reference to..... |
| 191412 | **Tablon** .. | ..We last heard from you on the..... |
| 191413 | **Tabloza** .. | ..Refer to our letter dated..... |
| 191414 | **Taboas** .. | ..Refer to our telegram dated..... |
| 191415 | **Taboinha** .. | ..We refer to your letter dated..... |
| 191416 | **Tabolagem** .. | ..We refer to your telegram dated..... |
| 191417 | **Taboleiro** .. | ..Have you received our order for..... |
| 191418 | **Taboleta** .. | ..We have not received your order for..... |
| 191419 | **Tabooed** .. | ..Please send necessary instructions. |
| 191420 | **Taboriten** .. | ..Please send confirmation by letter. |
| 191421 | **Tabouer** .. | ..We forward by steamer advertised to close on the..... |
| 191422 | **Tabouret** .. | ..Can you forward by the..... |
| 191423 | **Tabourine** .. | ..The Bill of Lading must be to the order of..... |
| 191424 | **Tabraca** .. | ..The Bill of Lading must be sent to..... |
| 191425 | **Tabrimon** .. | ..The Bill of Lading has already been sent to..... |
| 191426 | **Tabual** .. | ..The Bill of Lading has not been received. |
| 191427 | **Tabuda** .. | ..Delivery cannot be made until we have the Bill of Lading. |
| 191428 | **Tabularize** .. | ..Have you received the Bill of Lading. |
| 191429 | **Tabulating** .. | ..Insure to cover cost, freight and insurance. |
| 191430 | **Tabulista** .. | ..Insure to cover all charges and risks if latter is possible. |
| 191431 | **Taburno** .. | ..We accept your order for..... |
| 191432 | **Tacahout** .. | ..We accept your order dated..... |
| 191433 | **Tacamaca** .. | We cannot accept your order on terms proposed, please refer to our offer. |

N.B.—The code numbers are for use in case a repetition of the telegram may be necessary.

### EXAMPLES OF CODE TELEGRAMS.

The following exchange of Telegrams shows the mode in which the Code may be used:—A correspondent telegraphs "Taaldeel Aalmoezen 1400" which, on reference to the Code will be found to translate as follows: "Telegraph how soon and at what price, packed and delivered f.o.b. English port, you could supply and ship the following, viz.:—One Collmann Compound Engine of 250 Indicated Horse Power, price £1400.

The reply to this was "Tabicar Aalmoezen Tabiquemos 1400" which reads as follows: We can deliver in six weeks One Collmann Compound Engine of 250 Indicated Horse Power; replying to your telegram our price, subject to prompt confirmation of order, will be £1400."

On receipt of this our correspondent telegraphed: "Tabacales Aalmoezen Tabacosas" which reads: "Please supply and ship as soon as possible by mail steamer the following goods, engaging freight and insurance, free of all risks, if latter is possible, One Collmann Compound Engine of 250 Indicated Horse Power; payments will be made by....."

# CONTENTS

AND CODE WORDS FOR USE IN CONJUNCTION WITH APPLEBY'S COPYRIGHT TELEGRAPHIC CODE.

SECTION I.

# PRIME MOVERS.

# STEAM ENGINES AND BOILERS.

The word "economy" recurs so frequently in the following pages and is capable of such widely differing interpretation, that it may be well to define the sense in which this word is used. It is not intended to refer to low first cost, but to the judicious outlay of capital commensurate with the conditions to be fulfilled.

A large power continuously employed justifies the outlay for motive power which will work with the utmost economy, but the same cannot be said if the work is intermittent or fuel so cheap as to be comparatively worthless. Consideration must also be given to the cost of the plant up to entire completion and to that of fuel, labour and everything necessary for efficient working and maintenance. Where the cost of water for condensation—if procurable in sufficient quantity—is high, the best result will probably be obtained from the use of high pressure steam in conjunction with compound, treble or quadruple expansion engines and the following approximate data may be useful to purchasers who have not the advantage of advice on these subjects from experienced engineers.

**Consumption of fuel.**—For engines and boilers of the types referred to, the consumption of good coal, per indicated horse power per hour, may be expected to be approximately as follows :—

**Compound Condensing Engines** about 2 lbs.

**High Pressure Condensing Engines** about 2½ lbs.

High pressure non-condensing engines about 3 lbs., the last however does not apply to non-condensing engines of the Collmann, Corliss, &c. class, which work on a very low consumption of fuel.

**Feed Water for Boilers.**—This may be estimated at about 2¼ gallons per indicated horse power per hour.

**Water for Condensation.**—The variations in the temperature of the condensing water and of the exhaust steam, render it necessary that the quantity should be defined in each case ; this may vary from about 50 to 80 gallons per indicated horse power per hour.

**Maintenance.**—Attention should also be given to the probability—which as far as possible should be reduced to a certainty—that the plant will be capable of working continuously with ordinary repairs and with a minimum risk of loss arising from the stoppage of the engine, whether on land or at sea.

Amongst other matters to be considered—as many owners of engines know to their cost—are the absence of noise and vibration and of the emission of smoke.

Examples of other conditions which have had to be considered by engineers could be given almost *ad infinitum* but the foregoing remarks direct attention to the lines of thought bearing on these subjects and the following is an example of one phase in the selection of plant.

The Writer was instructed several years ago to prepare designs and estimates for turbines to work with a low fall and drive a factory which, closer investigation showed, could not be worked more than three or four months in the year. It was found that the cost of the installation, including turbines, pipes and provision for head and the tail race, would be so large, that interest on capital alone, would more than cover the total cost of steam engine power, calculated on the above mentioned basis. The inexpensive engine put down, (which did not require the attention of a skilled mechanic) with a water heater between the engine and the boiler, has given results satisfactory alike as to economy and durability. Many cases could however be cited—and they are unfortunately but too common—where the last named conditions have been absolutely reversed.

**BOILERS.**—The cost of steam as a motive power depends so largely on the efficiency of the boiler, and on the condition in which the steam enters the cylinder, that it may be well to preface the reference to most types of engines and boilers, which will be found in the following pages, by the subjoined extract from *The Engineer* on evaporation and moisture in steam.

After directing attention to the difference between the modern high pressure boilers and those of thirty or forty years ago, *The Engineer* writes as follows :—

"Most persons hold that the process of making steam consists in causing water to boil. They are right to a certain extent. It is indispensable for practical purposes that water should be made to boil, but the method and manner and place of boiling have all to be considered. We put water, so to speak, into the bottom of a boiler, and we take steam out of the top of it to drive our engines. What goes on inside the boiler may be fairly simple or very complex. It must not be taken for granted that simplicity is essential to the production of good steam. The excellence of steam depends on its dryness. If it is free from suspended water, it is tolerably certain to be quite clean and free from grit or impurity to cut up the surface of the cylinder, or the face on which the valve slides.

Now all steam as produced is wet ; it cannot be otherwise. It comes from some place below the surface of the water, and bursts up through that surface, entraining water with it. If we blow air up through water it will carry spray up to a considerable height. No doubt precisely the same action takes place with steam, and the water is not carried to the engine simply because the spray falls again by its own weight. If it were possible to take specimens at various levels in the steam space of a marine boiler, it would be found that for a distance of a couple of inches above the surface of the water, the steam was extremely wet, a little higher it would be drier, and so on ; first because the particles of water are not thrown up with sufficient velocity to carry them far when the water surface is large, and secondly because the steam loses velocity and allows the drops to settle, just in the same way that chaff falls when the current of air from a winnowing machine loses its velocity. Given time and space enough, and steam will drop suspended water, and the dropping may be hurried by causing the steam to strike against a surface, and in other ways well known to those who make separators. For ourselves, we believe that all steam as originally made is the same, and that it is much too wet for use. What its subsequent quality will be in the matter of dryness depends wholly on the treatment it receives. Thus a very large steam space may be provided, in which the water will fall to the bottom, just as mud is deposited in a stagnant pool ; or strainers may be used ; or expedients for inducing the running together of the mist particles, and their consequent deposition. But the main feature on which we now wish to insist is, that no boiler generates dry steam.

In all cases the steam is at the outset very wet. It is, so to speak, born wet. The circumstance that it subsequently becomes dry, bears testimony to the truth that no steam, as made, is fit for use without subsequent treatment. In the same way, coal gas as first made, cannot be used. It has to be washed and dried and purified in various ways. It is true that all the complex apparatus of a gas factory ostentatiously asserts itself, while the arrangements for the after treatment of steam are few and simple ; but the work they do is none the less important and indispensable. But if it is once conceded that all steam is the same at the outset, it matters nothing how wet it is on production. We may make it any way we please, if only we can subsequently so treat it that it shall be good and fit for work. Herein lies the secret of success in working water-tube boilers.

It cannot for a moment be doubted that the steam which issues from the end of a Thornycroft or Yarrow tube, is as wet as possible. Indeed, the weight of water discharged from the tube each moment, is far in excess of the weight of steam. That the steam in a Thornycroft boiler is subsequently fit for use, is due very largely to the fact that the water is propelled downward at a high velocity, the steam taking almost at once a different direction. Let us, for example, have a steam pipe running in a certain direction, and out of the side of it, at right angles, let a branch pipe open. If now steam is moving at a high speed in the first pipe, any water which it contains will be carried by its momentum in a straight line past the orifice to the branch pipe. The steam can turn suddenly at right angles, but the water cannot. The steam plays the part of a hare which doubles and escapes the greyhound, who continues straight on for some yards. From all this it follows that, so far as the subsequent quality of steam is concerned, it matters nothing whether it is generated in a small tube of great length, with a water surface only equal to the cross-sectional area of the tube, or in a big marine boiler, or in any other way. This leaves the hands of the boiler designer free in one direction at all events."

**Powers of boilers.**—Although the consumption varies considerably with engines of different types, about 20 lbs. of steam per indicated horse power per hour may be regarded as an ample supply for a good engine, so that as will be seen further on the "nominal" horse power of both engines and boilers greatly exceeds that required to develop a given "indicated" horse power.

**Nominal horse power** (N.H.P.).—This term is used not because it is deemed the best or the most accurate, but because it has been and still is so generally employed and understood. As applied to boilers, it usually means that if the construction and proportions of boiler, chimney, &c. are good, the boiler will be capable of evaporating 1 cubic foot (62.4 lbs.) of water for each N.H.P. per hour.

**Indicated horse power** (I.H.P.).—The figures in the following tables being based on a consumption of 20 lbs. of steam for each I H.P., it follows that there is a large margin between this and the N.H.P. These figures can however only be approximately correct because—as above indicated—different types of engines give different results, some using less and others more than 20 lbs. of steam per I.H.P. per hour.

**Brake horse power** (usually expressed B.H.P.) is the "brake" or "effective" power developed, exclusive of that consumed in working the engine. The quantity of power so consumed varies with the type and condition of the engine, but 10 to 15 per cent. is a usual allowance for this purpose, so that if 60 B.H.P. is required the boiler should be capable of supplying steam for 69 (say 70) I.H.P., plus a suitable allowance to cover the losses due to imperfect provision for preventing radiation, condensation, &c.

**Evaporative efficiency of boilers.**—In preparing the following table which gives the comparative evaporative capacity per lb. of coal used, to be expected from boilers of the types mentioned, it has been assumed that the coal is good and the stoking efficient.

With feed water entering the boiler at a temperature of 212°, few kinds of coal will theoretically evaporate more than 14½ lbs. of water per lb. of coal used. Allowing 7 per cent. for waste in ash, &c., this is reduced to about 13½ lbs. but, in practice, even with the high boiler efficiency of 70 per cent., more than 8½ lbs. of water will rarely be evaporated for each pound of good coal consumed.

COMPARATIVE EFFICIENCY OF BOILERS.

| | | | | | | |
|---|---|---|---|---|---|---|
| Lancashire and Cornish boilers, | Fig. 1516 and 1517, | .. | 8 to 9 lbs. | of water | per lb. | of coal. |
| Semi-Multitubular | ,, Fig. 1519 | .. .. | 8 to 11 lbs. | ,, | ,, | ,, |
| Multitubular | ,, Fig. 1520 to 1524 | .. | 8 to 11 lbs. | ,, | ,, | ,, |
| Vertical cross tube | ,, Fig. 1525 | .. .. | 5½ to 7½ lbs. | ,, | ,, | ,, |
| Marine | ,, Fig. 1527 and 1528 | .. | 8 to 9½ lbs. | ,, | ,, | ,, |

**Water heaters or economizers.**—If these are used the feed water is heated to about 212° and freed from many impurities, and the evaporating capacity of the boiler is increased by 10 to 15 per cent.

**VALVE GEARS.**—Of those mentioned in the following remarks, the gear invented by Mr. A. Collmann (a valued former assistant and friend of the writer) deserves to be better known than it is, and, for that reason is referred to at greater length than other and better known gears.

The cost of engines with Collmann gear is about the same as that of other high class engines of equal power and the cost of maintenance is exceptionally low. With regard to economy it may be sufficient to mention that the consumption of steam in the engines illustrated by Fig. 1500, is 16 lbs. of steam per indicated horse power per hour, when worked with a boiler pressure of 120 lbs. per square inch.

Mr. Collmann points out that, although great differences exist in the arrangement of parts devised for controlling the admission of steam to the cylinder, they may really be classified under two categories :—

1.—Gears which have two valves, one a slide valve with a constant motion, the other being an expansion valve working on, or in, the slide valve.

2.—Gears where two steam and two separate exhaust valves are used, the steam valves being moved by cams or by catches. In the latter case the valve is allowed to close suddenly by the catches coming out of gear.

The well known arrangement of valves referred to in paragraph 1 have been found more or less unsatisfactory when applied to engines of large power, but the extent to which they have been used clearly indicates that this type possesses many advantages.

Amongst these may be mentioned the positive motion which is given to all moving parts, whereby a reliable and durable action is maintained. They are however, open to the very grave objection that the action of the governor is uncertain, by reason of its having to overcome considerable resistance when varying the position of the cut off valve.

The 2nd category comprises valves which are actuated by cams and includes many devices, most of which give only a limited number of degrees of cut off and are subject to great wear and tear, and at the same time offering too much resistance to the governors which control the degree of cut off.

Amongst those last referred to may be mentioned the Corliss and Sulzer gears which open the steam valve by catches, the governor determining the point at which the catches are released and so regulate the degree of cut off. The valve, when released, is closed by means of weights, or by steam or by spring pressure against the action of an air or other buffer, to diminish the shock and noise that would otherwise be caused by the sudden closing of the valve.

The latter class has found considerable favour on account of the small resistance opposed to the action of the governor, and is extensively used, but Mr. Collmann considers that gears of the Corliss and similar type are open to the following grave objections:

1. The closing of the steam valve after the removal of the catches, is dependent upon the uncertain action of the weights, springs, or steam pressure operating against an increasing resistance offered by air or other buffers, thus leaving the most important part of the action—that which determines the speed of the cut off and thereby the value of the engine—to unreliable influences such as those referred to in the following paragraphs, *a*, *b*, and *c*:

*(a)* The amount of closing power, whether obtained from weights, springs or similar means, frequently varies—even under the most favourable conditions.

*(b)* The resistance offered to the closing of the valve by air, or other buffers, can never be kept constant.

*(c)* The resistance caused by friction of the moving parts, especially between the stuffing boxes and the valve rods, is continually changing.

2. The effects produced by these influences are, that the valves become damaged and leak in consequence of being closed too quickly, or they close too slowly by reason of the too energetic action of the buffers and of too great friction. In either case the engine gives results as regards consumption of fuel per horse power, and generally in economy, far below what had been anticipated.

3. The catches must frequently be renewed, and this, together with the difficulty in the maintenance of the air—buffers and springs, involves the employment of high class and expensive attendants.

**THE COLLMANN ENGINE.**—After carefully considering the advantages and disadvantages of the existing valve gears, Mr. Collmann designed that indicated in Fig. 1500, which combines the good qualities of the instantaneous cut off gears above referred to, and, in his opinion, is free from the disadvantages mentioned in the foregoing remarks. The advantages claimed consist in:

**Determined motions.**—The valve does not drop, but is quickly raised and lowered by the gear against the power for closing the valve. This is much larger than is (theoretically) required and only provides a rigid connection between the gear and the valve, whilst the latter is open.

The surplus closing power for the valve being taken up by the gear itself, the action is independent of the measure of this power, as well as of the extent of the frictional resistance of parts.

**Speeds.**—The gear admits of the valve being closed at the highest speed consistent with durability, and, as this speed is unchangeable, the gear works at the highest efficiency until it has been worn out by lengthened and continuous use whilst, in the previously mentioned gears, the closing speed must be kept below the maximum to avoid damage arising from the valve being closed too quickly.

**Action of Governors.**—The resistance to the action of the governors is so small, that steam at full pressure is supplied to the cylinders at each stroke of the engine and in exact proportion with the work done; even when working against greatly varying resistances, the speed of the engine is steadily maintained.

**Wearing Surfaces.**—These are exceptionally large in the Collmann gear and not liable to derangement.

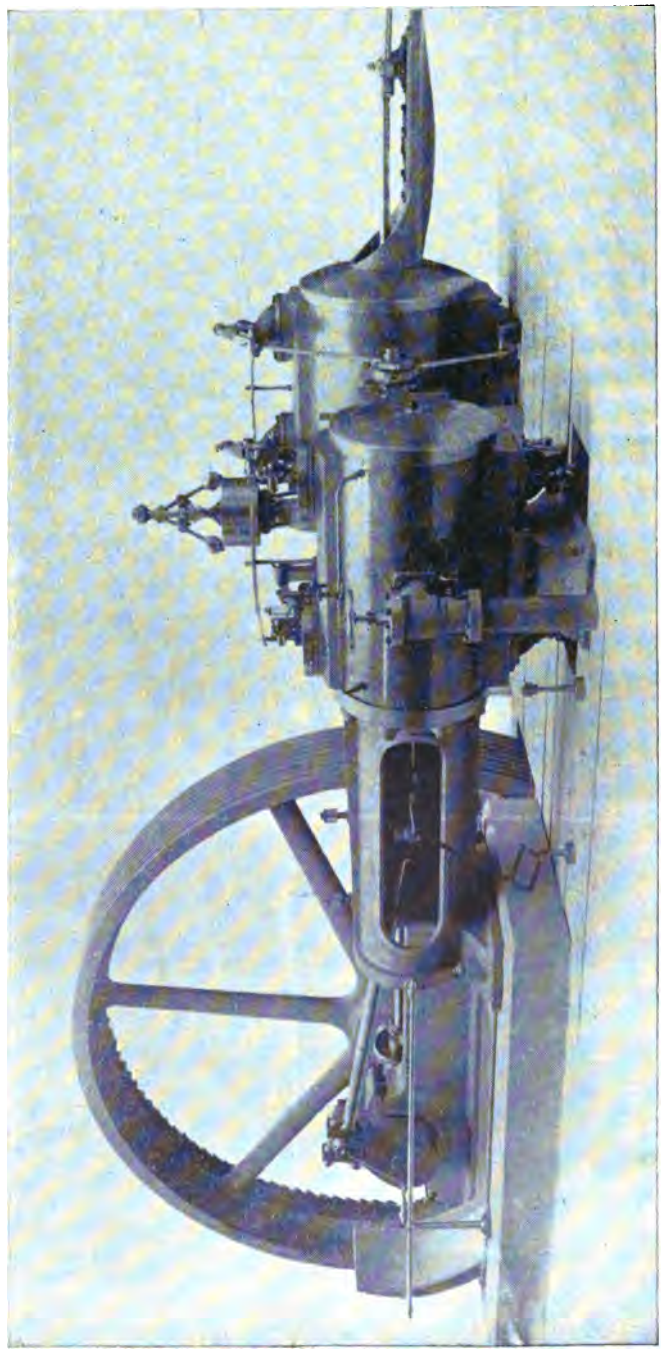


Fig. 1500.

**Revolutions.**—From the foregoing remarks it will be seen that engines with this gear, may be run at speeds up to about 100 revolutions per minute.

**The steam admission valves** are operated by the combination of two motions, one of which is constant, whilst the other is variable; the opening and closing of these valves therefore vary in proportion with the variation of the changeable motion.

**Point of cut off.**—The gears are capable of cutting off steam, at from one one-hundredth, to nine-tenths of the stroke.

**COST OF ENGINES** with Collmann valve gear. This is given approximately in the following table, it is however always desirable to make special estimates on designs, based on data relative to the maximum and average power required, the steam pressure at command, the speed in revolutions per minute, the water supply if condenser is required, the floor space available, &c.

If the space in the engine room is restricted, the high and low pressure cylinders are arranged side by side and carried on massive standards of box section. The cost is about the same as for engines of the type Fig. 1500.

In other cases the "tandem" arrangement is adopted, the low pressure cylinder being behind the high pressure cylinder. The cost of these is about 10 per cent. less than for the side-by-side engines, Fig. 1500.

About 100 indicated horse power is the limit below which it is usually undesirable to adopt the compound system, and it will be understood that engines of powers between and above those given in the following table, will be approximately proportionate with those given for the sizes now enumerated.

The term, "nominal horse power," so inadequately represents the duty of engines working with high pressure steam and at high piston speeds, that the expression, "indicated horse power," for engines of this type has been adopted as being more accurate and convenient.

**COLLMANN COMPOUND ENGINES.**—The illustration Fig. 1500, is a reproduction from a photograph of a Collmann engine of 250 horse power, which is working with 16 lbs. of steam per indicated horse power, the boiler pressure being 120 lbs. per square inch.

PRICES OF COLLMANN COMPOUND ENGINES, Fig. 1500.

| | | | | | | |
|---|---|---|---|---|---|---|
| Indicated horse power .. .. | 100 | 150 | 200 | 250 | 300 | 350 |
| Price of engine .. .. .. | £800 | £1000 | £1200 | £1400 | £1550 | £1700 |

The cost of packing for shipment and delivery f.o.b. is usually about 5 or 6 per cent.

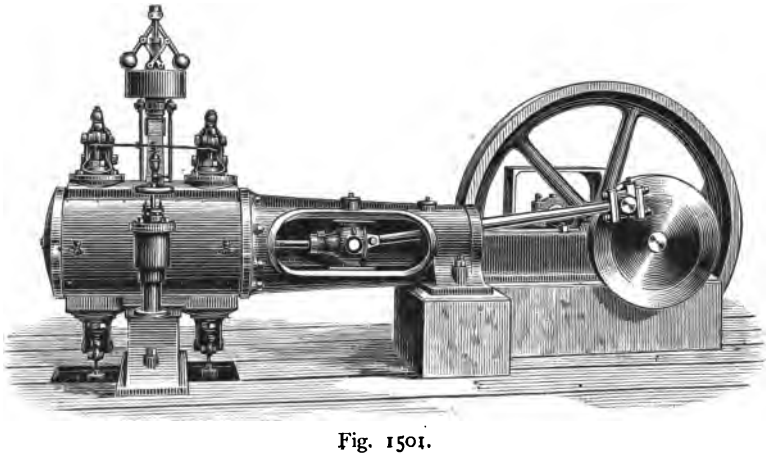


Fig. 1501.

**SINGLE CYLINDER COLLMANN ENGINES.** — The type Fig. 1501 is adopted with much economy and advantage, for engines up to about 200 nominal horse power and the approximate prices, with and without condenser, air pump, &c., are as follows. The boiler pressure is assumed to be 100 lbs. per square inch.

PRICES OF SINGLE CYLINDER COLLMANN ENGINES. Fig. 1501.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Indicated horse power .. .. .. | 50 | 60 | 80 | 100 | 130 | 150 | 180 |
| Diameter of cylinder .. inches.. | 13 | 14 | 16 | 18 | 20 | 22 | 24 |
| Length of stroke .. ,, .. | 24 | 28 | 32 | 36 | 42 | 48 | 48 |
| Revolutions per minute .. .. .. | 100 | 90 | 75 | 70 | 60 | 55 | 55 |
| Price of engine .. .. .. .. | £265 | £330 | £410 | £440 | £495 | £550 | £605 |
| Price of condenser, &c. .. .. .. | £50 | £55 | £75 | £100 | £125 | £150 | £175 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

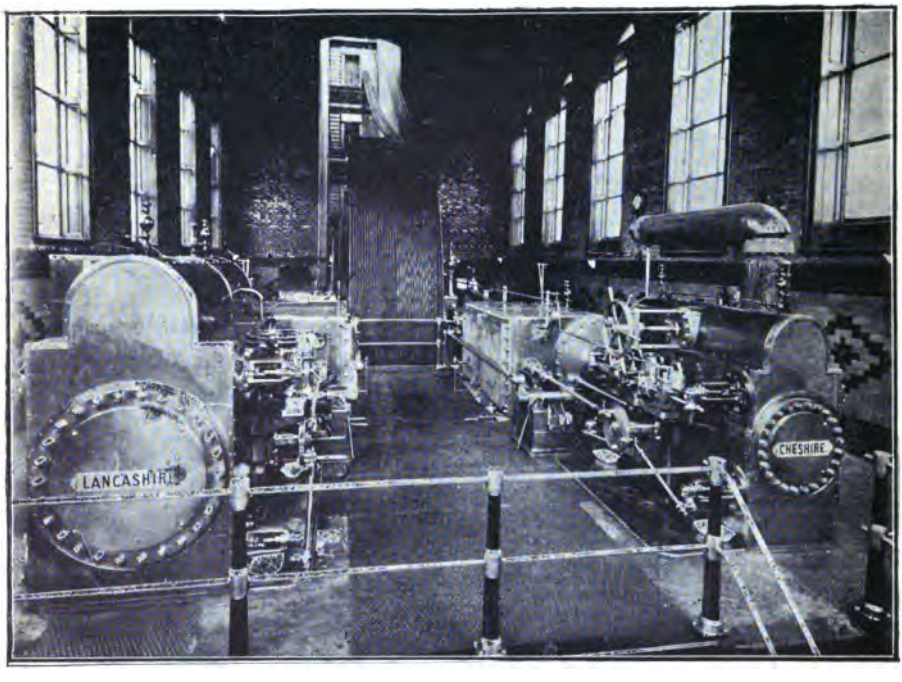



Fig. 1502.

**CORLISS ENGINES.**—One of the numerous combinations of this well known type of motor and valve gear, is shown in Fig. 1502, and as the construction does not differ materially from that of other high class engines, excepting as to the Corliss valve gear, the following brief description, in conjunction with the engraving, will probably suffice. Further details, price, &c., of single cylinder, compound, side by side, or tandem engines, with or without condensers, of any desired power, will be furnished when desired.

**The cylinders** are steam jacketted, encased in polished sheet iron, and fitted with steam inlet, outlet and air valves; the cylinder covers and valve box bonnets are also clothed with non-conducting materials, to minimise radiation of heat.

**The Corliss Valves** are of the most approved design and construction, and are provided for both the high and low pressure cylinders, the steam and exhaust valves being worked by separate eccentrics and separate gears. The steam valve rods of both cylinders, are fitted with release gears, controlled by the governor, whereby the cut off may be adjusted, the speed regulated and the load equally distributed between the two engines.

**The working surfaces** of the valve gears are of steel, carefully hardened; the air cushion cylinders and springs, have the proportions requisite to give great durability and are provided with air cushion valves arranged to work with very little noise.

**The Governors** of the quick speed type, driven by gear from the crank shaft, are very sensitive and of ample power. The speed adjustments, or isochronous motions, admit of the governors being set to completely control the revolutions of the engine under great variation of load and when working with light loads. There is also a sensitive knock-off apparatus which automatically breaks the connection with the governor and prevents the steam valve from opening in case of accident.

**The Crank Shaft** is of forged mild steel, enlarged to carry the fly wheel; the journals are of ample proportions and are supported in heavy gun metal bearings, adjustable horizontally by wedges and screws.

**The motion work** is carefully fitted and finished throughout and the several parts are made of the materials best adapted in each case.

**The Condenser, Air Pumps, &c.** have the dimensions requisite for working with the highest economy. The air pump is worked from the crosshead of the piston rod, by a steel lever with link connection and coupled to the bucket rod by crosshead and guides, wrought iron links with gun metal journals, &c.

**The Accessories** consisting of main steam stop valve, pipes to high pressure cylinder and between the high and low pressure cylinders, indicator gear, barring arrangements, steam and vacuum gauges, drippers, hand railing, chequered iron floor plates, &c. are usually supplied with each set of machinery.

**COMPOUND CONDENSING ENGINES,** of the type illustrated by Figs. 1503 and 1504, effect a saving in fuel equivalent to about one pound of coal per indicated horse power per hour, and the dimensions of boilers may be about 20 per cent. less than those required for non-condensing engines of equal power.

If a surface condenser is used, salt or brackish water may be used for circulation and a supply of pure water insured for feeding the boilers.

The engine Fig. 1503, is of 250 indicated horse power and has a surface condenser with Muntz metal tube plates and tubes, brass lined circulating and air pumps and all accessories necessary for working with salt water. The price of the engine is about £1200, or £150 more than for a similar engine with the jet condenser, which is included in the following prices. It will be understood that any of these engines will be provided with surface condensers, at extra cost in proportion with their power.

The cylinders are steam jacketted and the admission of steam to the high pressure cylinder is controlled by an improved form of governor, which insures steady running under wide variations of load and of pressure of steam.

The engines are carefully designed and finished and are complete with main steam stop valve, drain cocks and lubricators to cylinders, gun metal valves, drippers, foundation bolts and plates and all usual accessories. The crank shaft is of mild steel, swelled to take the fly wheel which is of ample proportion and weight; the rim is truly turned and, at a small extra cost, will be grooved for driving ropes.

The condenser is behind the low pressure cylinder and the air pump is worked from an extension of the piston rod, as shown in the engraving.

The subjoined powers of engines are based on a boiler pressure of 100 lbs. per square inch and, as mentioned with reference to Collmann engines, it is not usually desirable to put down this type of less than about 100 indicated horse power.

PRICES OF COMPOUND CONDENSING ENGINES, Fig. 1503.

| Indicated horse power .. .. | 100 | 150 | 200 | 250 | 300 | 350 |
|---|---|---|---|---|---|---|
| Price of engine .. .. .. | £600 | £750 | £900 | £1050 | £1160 | £1300 |

The cost of packing for shipment and delivery f.o.b. is usually about 5 per cent.

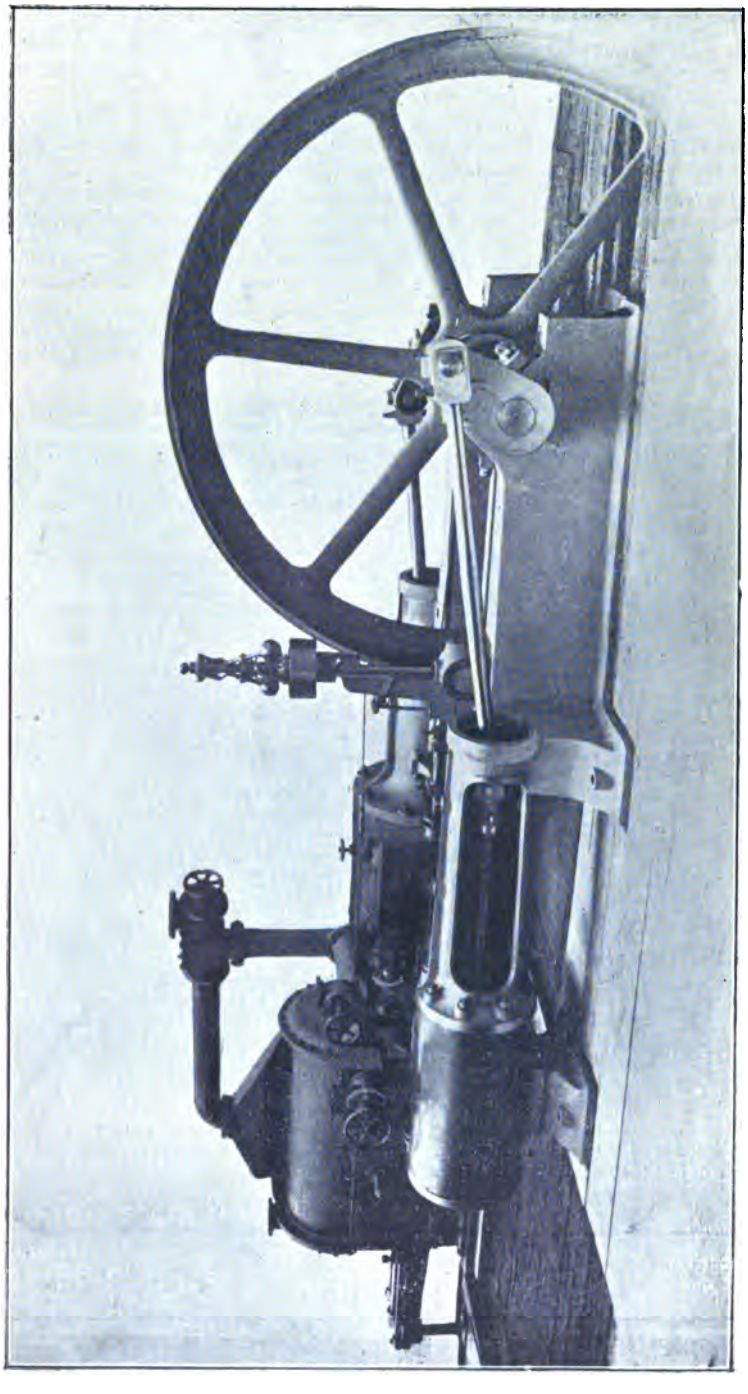


Fig. 1503.

**TANDEM COMPOUND CONDENSING ENGINES.**—The proportions of cylinders and other parts are precisely the same as those used in the construction of side by side engines, Fig. 1503, but, to save floor space, the high and low pressure cylinders and the condenser are in line.

These engines are made "right hand" or "left hand," so named from the fly wheel and outer bearing for the crank shaft being respectively on the right or left side, when viewed from the condenser end. The side required should be explicitly stated and if the correspondence is by cable, the word "right" or "left," after the code word given in the index, will be a sufficient instruction.

PRICES OF TANDEM COMPOUND CONDENSING ENGINES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Indicated horse power ... ... | 100 | 150 | 200 | 250 | 300 | 350 |
| Price of engine ... ... ... | £525 | £650 | £780 | £910 | £1000 | £1130 |

**VERTICAL COMPOUND CONDENSING ENGINES.**—When the vertical arrangement is more convenient than either of those last referred to, the steam cylinders are carried on massive standards and columns supported from the base plate, the condenser being fixed below and the circulating and air pumps worked from a rocking lever in the usual manner.

The dimensions of cylinders, &c., are the same as for the horizontal type Fig 1503 and—approximately—the prices are the same.

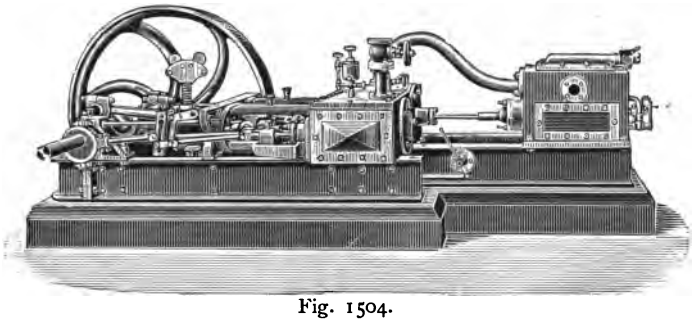


Fig. 1504.

**HORIZONTAL COMPOUND ENGINES.**—The arrangement of compound engines with or without condensers shown in Fig. 1504, has been designed with a view to compactness and a minimum weight of parts, which is so essential in many cases.

The bearings, cylinders and condenser are secured to a steel girder frame which forms the bed plate and is sent out whole, or in parts easily put together at destination. The cylinders are steam jacketted and covered with felt and planished steel casing. The expansion valve is worked automatically from the governor, the bearings and wearing surfaces are of ample proportions, and the engines are designed throughout for steady running and permanent work.

The powers mentioned in the following tables are those obtained with a boiler pressure of 100 lbs. per square inch.

**Tandem Engines**, with the same proportion of parts as the side by side engines illustrated, are made at the subjoined prices.

PRICES OF COMPOUND ENGINES, Fig. 1504.

| | | | | | | |
|---|---|---|---|---|---|---|
| Nominal horse power .. .. | 16 | 20 | 25 | 30 | 40 | 50 |
| Best working horse power .. | 40 | 50 | 65 | 80 | 110 | 130 |
| Diam. of small cylinder inches | 8 | 9 | 10 | 11 | 13 | 14 |
| Ditto large ditto ,, | 12¾ | 14 | 16 | 17½ | 20½ | 22½ |
| Length of stroke .. ,, | 16 | 16 | 18 | 18 | 24 | 24 |
| Diameter of fly wheel feet | 6 | 6½ | 7 | 8 | 9 | 9½ |
| Revolutions per minute .. | 135 | 135 | 120 | 120 | 90 | 90 |
| Price of engine side by side .. | £260 | £300 | £360 | £420 | £595 | £750 |
| Ditto ditto tandem .. | £230 | £265 | £320 | £470 | £530 | £605 |
| Ditto jet condenser .. .. | £55 | £60 | £70 | £75 | £85 | £100 |
| Ditto surface do. .. .. | £120 | £140 | £170 | £200 | £270 | £300 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**COMPOUND SHORT STROKE ENGINES** of the construction shown in Fig. 1506, will work with steam at any pressure up to about 150 lbs. per square inch and are largely used for driving dynamos and for many other purposes where space is limited and it is desirable to maintain a high and regular speed.

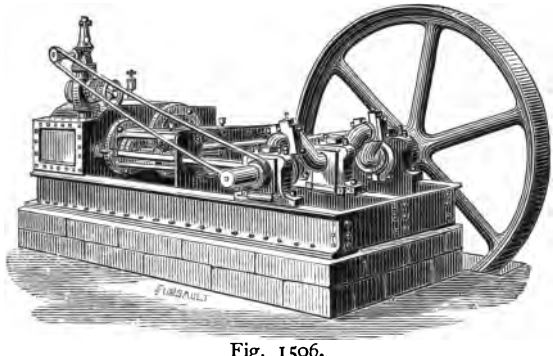


Fig. 1506.

The governors are of an improved type, the engines are carefully balanced and finished, and are provided with automatic expansion gear, sight feed lubricator, &c. The base consists of a steel girder frame for facility in re-erection and for a minimum charge for freight and import duties. With a working pressure of 100 to 120 lbs. per square inch, the engines develop quite three times the nominal horse power and higher power in proportion with increase in the steam pressure.

**Boilers.**—The various types of boilers used in conjunction with these engines will be found at pp. 24 to 38 but the locomotive boiler has so much to recommend it in economy of fuel, facility in erection, etc., that the prices of such boilers with fittings for a working pressure of about 140 lbs. per square inch and of suitable proportions, are included in the following tables. If an extra large fire box is required for firing with wood or inferior fuel, the extra cost is £1 per nominal horse power.

PRICES OF COMPOUND SHORT STROKE ENGINES, Fig. 1506.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal horse power ... ... | 8 | 10 | 12 | 16 | 20 | 25 | 30 | 40 |
| Best working power ... ... | 20 | 25 | 30 | 40 | 50 | 62 | 75 | 100 |
| Price of engine ... ... .. | £170 | £190 | £210 | £248 | £285 | £345 | £400 | £585 |
| ,, feed pump ... ... | £5 | £6 | £8 | £10 | £10 | £10 | £15 | £15 |
| ,, jet condenser ... ... | £30 | £35 | £40 | £50 | £60 | £75 | £80 | £90 |
| ,, loco. boiler ... ... | £135 | £145 | £157 | £192 | £235 | £295 | £345 | £480 |
| Diameter of fly wheel .. ft. | 5 | 5 | 5½ | 5½ | 6¼ | 7 | 7 | 8 |
| Revolutions per minute... .. | 180 | 180 | 155 | 135 | 135 | 120 | 120 | 90 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**HIGH PRESSURE SHORT STROKE ENGINES** with wrought iron base, are very compact and so closely resemble Fig. 1506 that another illustration is unnecessary.

The engines are fitted and finished in the same manner as those above referred to and—if provided with double slide valves and automatic expansion gear regulated by the governors—may be relied upon for economy and for maintaining a constant speed, even with widely varying loads. Many of these engines fitted with link motion reversing gear are in successful use for winding, hauling, &c.

PRICES OF DOUBLE CYLINDER SHORT STROKE ENGINES.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nominal horse power .. .. .. | 8 | 10 | 12 | 16 | 20 | 25 | 30 |
| Price of engine .. .. .. .. | £125 | £140 | £155 | £190 | £225 | £265 | £315 |
| Automatic expansion gear .. .. | £18 | £22 | £27 | £35 | £45 | £55 | £65 |
| Link reversing gear .. .. .. | £20 | £25 | £25 | £30 | £30 | £35 | £35 |
| Feed pump .. .. .. .. | £5 | £6 | £7 | £8 | £10 | £12 | £14 |
| Jet condenser .. .. .. .. | £40 | £42 | £45 | £55 | £65 | £75 | £85 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

PRICES OF SINGLE CYLINDER SHORT STROKE ENGINES.

| | | | | | | |
|---|---|---|---|---|---|---|
| Nominal horse power .. .. .. | 6 | 7 | 8 | 10 | 12 |
| Price of engine .. .. .. .. | £77 | £85 | £95 | £110 | £125 |
| Automatic expansion gear .. .. .. | £9 | £10 | £12 | £15 | £18 |
| Link reversing motion .. .. .. | £12 | £15 | £15 | £18 | £18 |
| Feed pump .. .. .. .. .. | £4 | £5 | £5 | £6 | £7 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

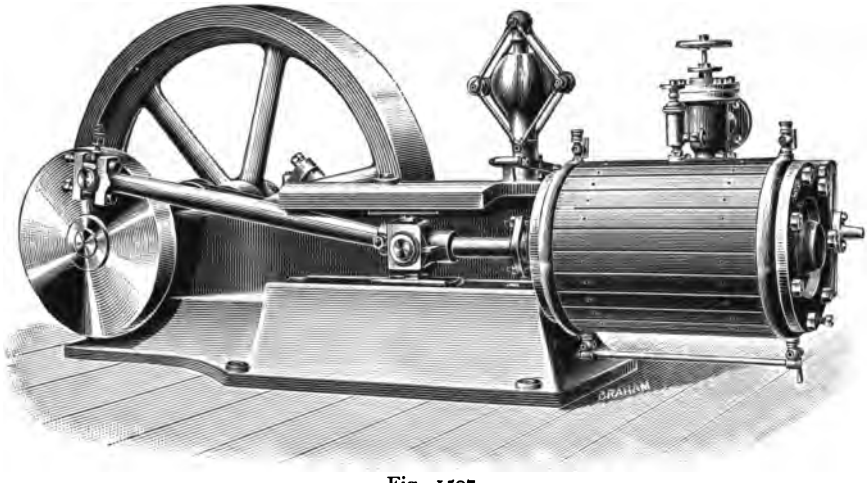



Fig. 1507.

**HORIZONTAL HIGH PRESSURE ENGINES** represented by Figs. 1507 and 1508, are of the well known type, self contained on the massive iron bed plate shown in the engravings.

**The steam cylinder** is felted and lagged with mahogany or covered with planished sheet steel, and is fitted with metallic piston and steel piston rod working in a long stuffing box, lined with hard gun metal. The guides, guide blocks and bearings, have large wearing surfaces easily adjusted and provided with the necessary lubricators.

**The governors** are of the high speed type and the larger sizes may be fitted, if desired, with automatic expansion gear.

**The fly wheel** is turned to take a driving strap and, for the larger sizes, the wheel is made in halves and carefully fitted, the boss being bored, key seated, &c.

**Fittings and accessories.**—The engines are sent out complete as shown and are tested in steam before delivery. The advantages derived, under some circumstances, from the use of a condenser or a water heater, are referred to further on and the costs of these accessories are given as separate items; also the extra cost of case hardened link reversing motion for engines required to work permanently, or temporarily, in connection with winding or hauling gear.

PRICES OF HORIZONTAL ENGINES, Fig. 1507.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nominal horse power... ... ... | 8 | 10 | 12 | 14 | 16 | 20 | 25 |
| Diam. of cylinder ... ... inches | 9 | 10 | 11 | 12 | 13 | 14 | 16 |
| Stroke of piston ... ... ditto | 16 | 18 | 20 | 24 | 24 | 28 | 30 |
| Price of engine... ... ... ... | £76 | £104 | £125 | £135 | £150 | £180 | £225 |
| Ditto feed pump ... ... ... | £5 | £6 | £7 | £8 | £9 | £10 | £15 |
| Ditto expansion gear ... ... | £12 | £15 | £18 | £22 | £25 | £30 | £35 |
| Ditto water heater ... ... ... | £16 | £18 | £20 | £22 | £25 | £30 | £35 |
| Ditto condenser ... ... ... | £45 | £48 | £50 | £54 | £60 | £63 | £68 |
| Ditto link motion ... ... ... | £12 | £14 | £17 | £20 | £22 | £25 | £28 |
| Approx. measurement cubic feet | 46 | 53 | 74 | 95 | 100 | 128 | 167 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

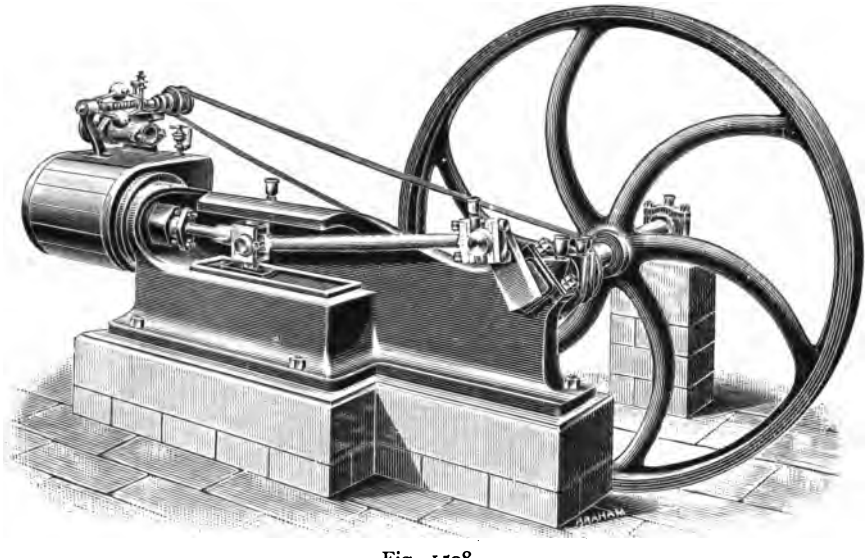


Fig. 1508.

PRICES OF HORIZONTAL ENGINES, Fig. 1508.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nominal horse power .. ... ... | 2 | 3 | 4 | 6 | 8 | 10 | 12 |
| Diameter of cylinder ... ... inches | 4½ | 6 | 6½ | 8 | 9 | 10 | 11 |
| Stroke of piston .. ... ditto | 7 | 8 | 10 | 14 | 16 | 18 | 20 |
| Price of engine ... ... ... | £25 | £33 | £38 | £60 | £74 | £98 | £113 |
| Ditto feed pump ... ... ... | £4 | £4 | £4 | £5 | £6 | £7 | £8 |
| Ditto link motion ... ... ... | £10 | £10 | £10 | £10 | £12 | £14 | £16 |
| Approximate measurement ... ... | 10 | 15 | 22 | 42 | 48 | 53 | 73 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.
For prices of vertical engines see page 17.

**COMPOUND UNDER-TYPE ENGINE WITH BOILER.**—The engine Fig. 1509 is similar in design and finish to that illustrated by Fig. 1506 but the base—also constructed of steel girders—is arranged to carry the boiler, the barrel of which, to economise space, extends over the engine as shown.

The cylinders are steam jacketted and fitted with expansion gear worked automatically from the governors. The wearing surfaces are of ample dimensions and are well lubricated, and with steam at 100 to 120 lbs. per square inch, the engines may be worked continuously to fully three times the nominal horse power, the boilers are however equal to a working pressure of 140 lbs. per square inch.

The water heater referred to below, consists of a series of solid drawn brass tubes arranged horizontally, and does good service in heating and in depositing the impurities in the feed water.

PRICES OF COMPOUND UNDER-TYPE ENGINES, Fig. 1509.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nominal horse power .. | 10 | 12 | 16 | 20 | 25 | 30 | 40 | 50 |
| Diameter of fly wheel feet | 5 | 5½ | 5½ | 6¼ | 7 | 7 | 8 | 8 |
| Revolutions per minute .. | 180 | 155 | 135 | 135 | 120 | 120 | 90 | 90 |
| Price complete with feed pump | £340 | £375 | £450 | £530 | £650 | £760 | £1080 | £1265 |
| Ditto of injector .. .. | £8 | £8 | £10 | £10 | £15 | £15 | £15 | £18 |
| Ditto water heater .. | £15 | £15 | £20 | £20 | £25 | £25 | £30 | £35 |
| Ditto enlarged fire box .. | £10 | £12 | £16 | £20 | £25 | £30 | £40 | £50 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

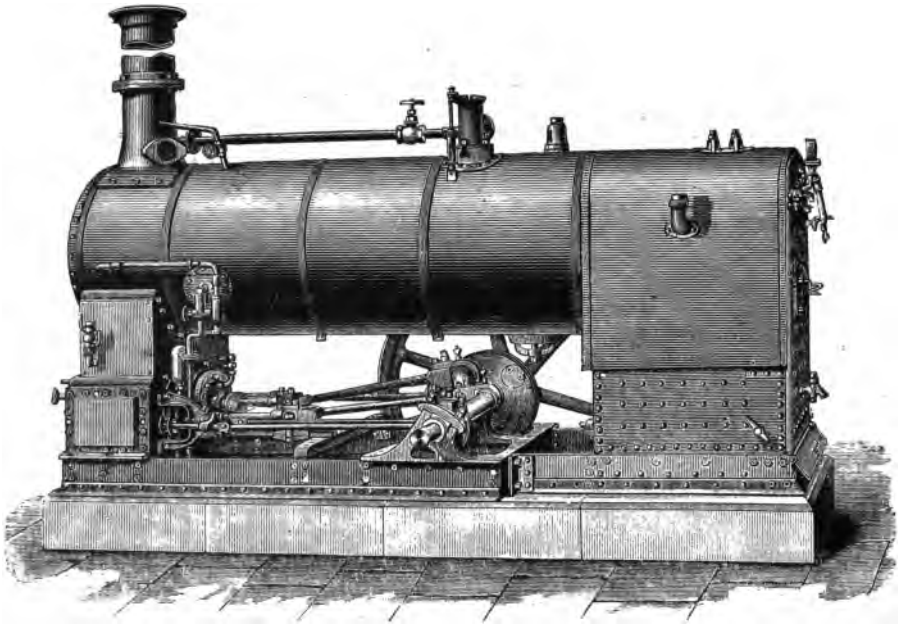


Fig. 1509.

**HIGH PRESSURE UNDER-TYPE ENGINES AND BOILERS** are arranged as shown in Fig. 1509 and are complete with governors, turned fly wheel, and the necessary accessories ready for work. The boilers are tested by hydraulic pressure to 160 lbs. per square inch and the engines may be safely worked to about three times the nominal horse power. The price for the extra length of crank shaft, which is frequently required to carry driving pulleys, includes a pedestal bearing for the outer end.

So far as the Writer is aware, the first engine and boiler constructed in the manner now referred to, was that contributed by his firm for driving the delicate machinery for spinning and weaving silk, in the Swiss section of the International Exhibition (London) in 1862.

PRICES OF DOUBLE CYLINDER UNDER-TYPE ENGINES AND BOILERS.

| Nominal horse power | 8 | 10 | 12 | 16 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| Price of engine | £235 | £265 | £305 | £375 | £450 | £540 | £640 |
| Automatic expansion gear | £18 | £22 | £27 | £35 | £45 | £55 | £65 |
| Extra length of main shaft | £8 | £8 | £9 | £10 | £12 | £13 | £15 |
| Feed water heater | £10 | £15 | £15 | £20 | £20 | £25 | £25 |
| Injector | £8 | £8 | £9 | £10 | £11 | £12 | £15 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

PRICES OF SINGLE CYLINDER UNDER-TYPE ENGINES AND BOILERS.

| Nominal horse power | 6 | 7 | 8 | 10 | 12 |
|---|---|---|---|---|---|
| Price of engine | £175 | £190 | £205 | £235 | £275 |
| Automatic expansion gear | £9 | £10 | £12 | £15 | £18 |
| Extra length of main shaft | £7 | £8 | £8 | £8 | £9 |
| Feed water heater | £10 | £10 | £10 | £15 | £15 |
| Injector | £8 | £8 | £8 | £8 | £9 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**SEMI-PORTABLE ENGINES AND BOILERS.**—The fire box and smoke box are supported on pedestals of suitable shape and height, instead of the engines being mounted on travelling wheels, but in other respects the engines are similar to the portable engines Fig. 1512.—The proportions are the same and the prices for accessories and additions apply equally to both types. For dimensions of compound semi-portable engines and for prices of accessories see page 19.

PRICES OF DOUBLE CYLINDER SEMI-PORTABLE ENGINES.

| Nominal horse power ... ... ... | 8 | 10 | 12 | 16 | 20 |
|---|---|---|---|---|---|
| Prices of compound engines ... ... | £290 | £320 | £345 | £420 | £500 |
| Ditto high pressure ditto ... ... | £220 | £250 | £285 | £355 | £425 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

PRICES SINGLE CYLINDER SEMI-PORTABLE ENGINES.

| Nominal horse power ... ... ... | 3 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|
| Price of engine ... ... ... ... | £125 | £140 | £170 | £195 | £225 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**THE COMBINED HORIZONTAL ENGINE AND BOILER,** Fig. 1510, is entirely self contained, and is adapted for driving pumps, dynamos, or other machinery, the governors being of the high speed type, with adjustments for regulating the speed and consumption of steam. The wearing parts have ample proportions and efficient lubricators are provided where required. The boilers have cross tubes and are made, by preference, of Siemens Martin steel, but they will be constructed of best Staffordshire iron or equal quality plates if desired; each boiler is proved by hydraulic pressure to 120 lbs. per square inch, and the engine and boiler are tested in steam before delivery.

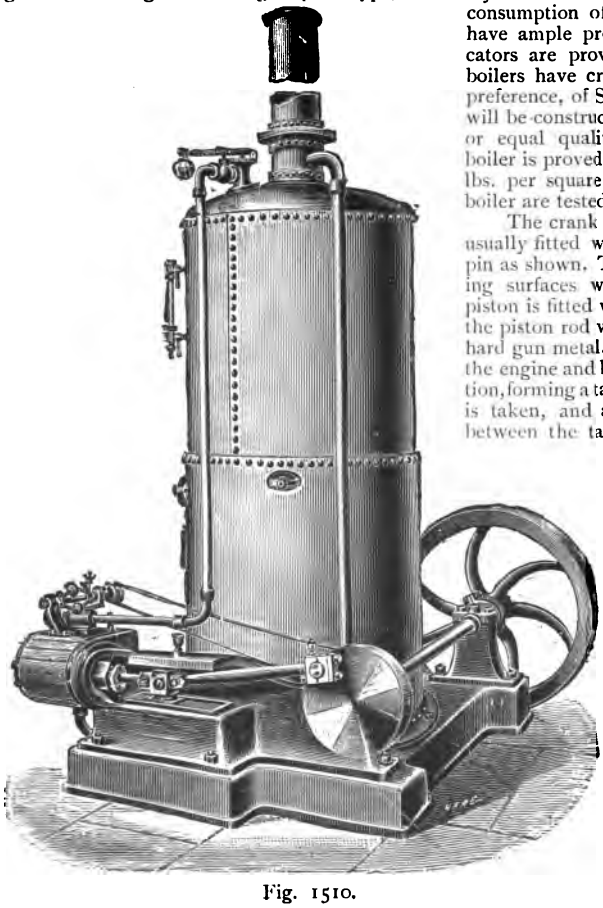


Fig. 1510.

The crank shaft is of mild steel, and is usually fitted with a turned disc with steel pin as shown. The crosshead has large wearing surfaces with adjustable slippers, the piston is fitted with Ramsbottom rings, and the piston rod works in a gland bushed with hard gun metal. The bed plate which carries the engine and boiler, is a casting of box section, forming a tank from which the feed water is taken, and all connections are provided between the tank, feed pump, and boiler, with the necessary valves, elbow for filling the tank, with brass screw cap, and all appliances for safe and efficient working. The boiler has a fusible plug in the crown of the fire box, and is fitted with fire door, fire bars, bearer, and chimney. Man hole and mud holes with covers are provided opposite each cross tube. The steam mountings consist of safety valve, steam pressure gauge, water gauge, two trials cocks, feed valve, and blow-off cock, and all pipes and connections are provided for the steam supply and exhaust, as shown.

PRICES OF HORIZONTAL ENGINES WITH VERTICAL BOILERS, Fig. 1510.

| | | | | | | |
|---|---|---|---|---|---|---|
| Nominal horse power .. .. .. | 2 | 3 | 4 | 5 | 6 |
| Height of boiler .. .. .. feet | 5 | 6 | 6½ | 7 | 7½ |
| Diameter of boiler .. .. .. ,, | 2¼ | 2½ | 2¾ | 3 | 3¼ |
| Price of engine and boiler complete .. | £59 | £69 | £85 | £95 | £115 |
| Felting and lagging boiler .. .. extra | £5 10 | £6 | £7 | £7 10 | £9 10 |
| Link reversing gear .. .. ,, | £10 | £10 | £10 | £10 | £10 |
| Feed pump .. .. .. .. ,, | £3 10 | £4 | £4 5 | £4 10 | £5 |
| Approximate weight .. .. cwts. | 22 | 25 | 32 | 36 | 43 |
| Ditto measurement cubic feet. | 55 | 75 | 95 | 115 | 145 |
| Nominal horse power .. .. .. .. .. | 8 | 10 | 12 | 14 |
| Height of boiler .. .. .. .. feet | 8¾ | 9½ | 11 | 11 |
| Diameter of boiler .. .. .. .. ,, | 3½ | 4 | 4 | 4¾ |
| Price of engine and boiler complete .. .. .. | £165 | £190 | £230 | £257 |
| Felting and lagging boiler .. .. .. extra | £11 10 | £13 | £14 | £16 |
| Link reversing gear .. .. .. .. ,, | £12 | £14 | £16 | £18 |
| Feed pump .. .. .. .. .. ,, | £5 5 | £7 | £7 10 | £8 10 |
| Approximate weight .. .. .. .. cwts. | 56 | 70 | 90 | 115 |
| Ditto measurement .. .. cubic feet | 185 | 250 | 315 | 425 |

The cost of packing for shipment and delivery f.o.b. is usually 5 per cent.

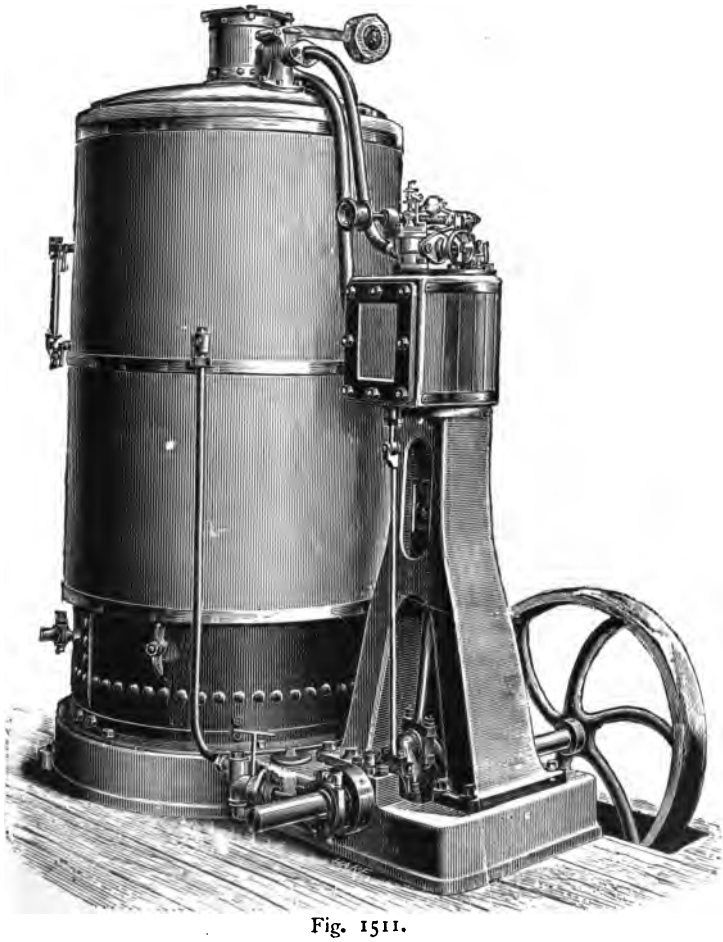


Fig. 1511.

**THE VERTICAL ENGINE AND BOILER,** Fig. 1511, mounted on a strong base plate, which forms a feed water tank, occupies a minimum of space for a given power, and is specially adapted for use where massive foundations cannot be conveniently provided, or where the engine must be frequently moved.

The standards which carry the steam cylinders and all the working parts have been specially designed to afford the necessary rigidity, the crank shaft is made from a single bar of mild steel and is arranged to take the fly wheel and pulleys at either end, the latter being turned to take a belt, or the fly wheel may be fixed at one end and the belt pulley at the other end of the crank shaft. The governors are of the high speed type and all necessary lubricators are provided, the feed pump is driven from the crank shaft by an eccentric as shown, and has a gun metal plunger and all connections, including gun metal valves between the pump and the feed water tank beneath the boiler. The boiler is of the cross tube type, and is complete with all mountings as described at pages 34 and 35.

PRICES OF VERTICAL ENGINES AND BOILERS, Fig. 1511.

| | | | | | |
|---|---|---|---|---|---|
| Nominal horse power .. .. .. | 2 | 3 | 4 | 5 |
| Height of boiler .. .. .. feet | 5 | 6 | 6½ | 7 |
| Diameter of boiler .. .. ,, | 2¼ | 2½ | 2⅝ | 3 |
| Price of boiler and engine complete .. | £56 | £72 | £89 | £101 |
| Felting and lagging boiler .. .. extra | £5 10 | £6 | £7 | £7 10 |
| Link reversing gear .. .. .. | £10 | £10 | £10 | £10 |
| Feed pump extra .. .. .. .. | £3 10 | £4 | £4 5 | £4 10 |
| Approximate weight .. .. cwts. | 26 | 34 | 38 | 45 |
| Approximate measurement cubic feet | 80 | 120 | 130 | 145 |
| Nominal horse power .. .. .. | 6 | 8 | 10 | 12 |
| Height of boiler .. .. .. feet | 7½ | 8¾ | 9½ | 11 |
| Diameter of boiler .. .. .. ,, | 3¼ | 3½ | 4 | 4 |
| Price of boiler and engine complete .. | £115 | £150 | £175 | £200 |
| Felting and lagging boiler .. .. extra | £9 10 | £11 10 | £13 | £14 |
| Link reversing gear .. .. .. | £10 | £12 | £14 | £16 |
| Feed pump extra .. .. .. .. | £5 | £5 5 | £7 | £7 10 |
| Approximate weight .. .. cwts. | 50 | 70 | 78 | 87 |
| Approximate measurement cubic feet | 160 | 230 | 310 | 380 |

Packing for shipment and delivery f.o.b. is about 5 per cent.

**VERTICAL HIGH PRESSURE ENGINE** (without boiler).—The engine is of the type illustrated in Fig. 1511, and the box section standard, which forms the guides for the crosshead, is secured to a bed plate of proportions suitable for bolting to masonry, concrete or timber foundations, if these should be necessary.

The cylinder is truly bored and is fitted with bright covers; the piston has metallic packings, the piston rod is of mild steel and works in a long gun metal gland; the crosshead has large surfaces and is arranged for adjustment to take up wear. The crank shaft is of mild steel and extends beyond the bearings on each side for convenience in transmitting power; and the engine is complete with high speed governors and all necessary accessories.

PRICES OF VERTICAL ENGINES, TYPE Fig. 1511.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nominal horse power ... ... ... | 2 | 3 | 4 | 6 | 8 | 10 | 12 |
| Price of engine... ... ... ... | £26 | £30 | £33 | £50 | £66 | £76 | £87 |
| Ditto feed pump ... ... extra | £4 | £4 | £4 | £5 | £6 | £7 | £8 |
| Ditto link motion ... ... ,, | £10 | £10 | £10 | £10 | £12 | £14 | £16 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

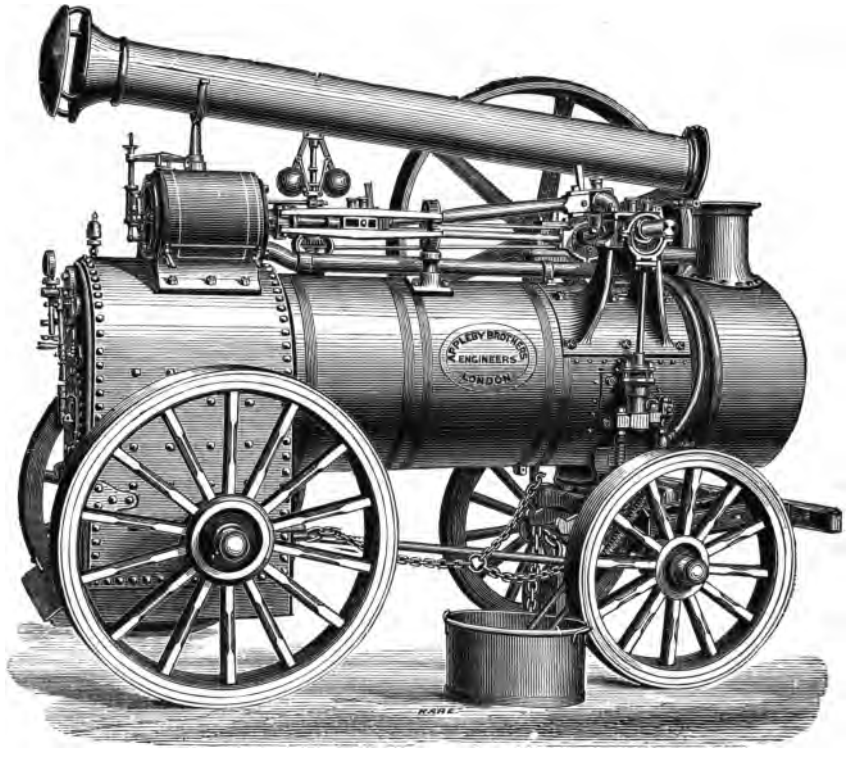



Fig. 1512.

**PORTABLE STEAM ENGINES,** illustrated by Fig. 1512 are so universally known that little need be said beyond reference, in general terms, to the materials used in their construction. These are of the highest quality and the parts throughout are carefully designed to give a maximum useful effect with low consumption of fuel and a minimum of wear and tear.

**The wearing parts** are made to gauges and, as mentioned further on, can at any time be sent ready for use if the number is given of the engine which requires renewals of this kind.

**The boilers** are constructed of mild steel or of the highest qualities of iron, flanged and rivetted by hydraulic machinery and tested by hydraulic pressure to 160 lbs. per square inch. In addition to the usual steam, furnace and feed water fittings, the boilers are provided with a second lock up safety valve, dial pressure gauge, steam whistle and feed water heater.

**The travelling wheels** are of wood or wrought iron (usually the latter) and are fitted with patent axle boxes, the front pair having swivelling fore carriage and shafts or poles for horses or oxen, as desired, skid and chain, &c.

**The cylinders** are steam jacketted and are clothed and encased in sheet steel cover to reduce condensation and loss by radiation of heat.

**The governors** are of the high speed class, unless the automatic expansion governor is adopted, to ensure exceptional regularity in the speed.

**The feed pump** works vertically as shown and continuously, auxiliary feed (if required) being provided by an injector, the price of which is mentioned in the following tables.

**Accessories.**—These consist of a set of firing tools, a set of spanners, tube brush and rod, spare gauge glasses and rings, oil can, water funnel, waterproof cover, &c.

**SPARE PARTS FOR PORTABLE ENGINES,** as referred to in the following lists of prices, are those most liable to wear and can be sent with the engines, or whenever required if the number of the engine is given, the several parts being made to gauge. The parts consist of:

Two pairs of gun metal bearings for crank shaft. A set of gun metal bearings for the large end of connecting rod. A set of straps for valve rods. Straps for feed pump rod. A set of piston rings. A set of furnace bars. Six gauge glasses with india rubber rings. A spring for safety valve. Gauge cock. Three tube brushes. A set of bolts for chimney joints. Six boiler tubes and ferrules.

The prices of accessories for compound portable engines and the weights and measurements are the same as those tabulated for double cylinder engines of the type Fig. 1512 of equal powers.

PRICES OF COMPOUND PORTABLE ENGINES.

| | | | | | |
|---|---|---|---|---|---|
| Nominal horse power .. .. .. | 8 | 10 | 12 | 16 | 20 |
| Diameter of high pressure cylinder inches | 5¾ | 6½ | 7 | 8 | 9 |
| Ditto low ditto ditto ,, | 9 | 10 | 11 | 11¾ | 14 |
| Length of stroke .. .. .. ,, | 12 | 12 | 14 | 16 | 16 |
| Diameter of fly wheel .. .. feet | 5 | 5 | 5½ | 5½ | 6¼ |
| Revolutions per minute .. .. .. | 180 | 180 | 155 | 135 | 135 |
| Price of engine .. .. .. .. | £310 | £340 | £375 | £450 | £530 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

PRICES OF DOUBLE CYLINDER PORTABLE ENGINES, Fig. 1512.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nominal horse power .. .. | 8 | 10 | 12 | 16 | 20 | 25 | 30 | 40 |
| Price of engine .. .. .. | £235 | £265 | £305 | £375 | £450 | £540 | £640 | £840 |
| Do. enlarged fire box extra | £12 | £15 | £18 | £24 | £30 | £38 | £45 | £60 |
| Do. automatic expansion gear ,, | £18 | £23 | £27 | £36 | £45 | £56 | .. | .. |
| Do. link motion reversing gear ,, | £20 | £25 | £25 | £30 | £30 | £35 | £35 | £45 |
| Do. injector and fittings ,, | £8 | £8 | £8 | £10 | £10 | £10 | £15 | £15 |
| Do. water heater .. ,, | £10 | £15 | £15 | £20 | £20 | £25 | £25 | £30 |
| Set of spare parts .. ,, | £16 | £18 | £20 | £25 | £29 | £33 | £38 | £50 |
| Approximate weight .. cwts. | 107 | 126 | 130 | 147 | 235 | 255 | 285 | 370 |
| Ditto measurement cubic ft. | 390 | 423 | 465 | 491 | 630 | 710 | 790 | 920 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

PRICES OF SINGLE CYLINDER PORTABLE ENGINES, Fig. 1512.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nominal horse power .. .. | 3 | 4 | 5 | 6 | 7 | 8 | 10 | 12 |
| Price of engine .. .. .. | £130 | £150 | 165 | £180 | £195 | £210 | £240 | £280 |
| Do. enlarged fire box .. extra | £4 10 | £6 | £7 10 | £9 | £10 10 | £12 | £15 | £18 |
| Do. automatic expansion gear ,, | £7 10 | £7 10 | £7 10 | £9 | £10 10 | £12 | £15 | £18 |
| Do. link motion reversing gear ,, | £10 | £10 | £12 | £12 | £15 | £15 | £18 | £18 |
| Do. injector and fittings ,, | £8 | £8 | £8 | £8 | £8 | £8 | £8 | £8 |
| Set of spare parts .. ,, | £6 10 | £7 10 | £11 | £12 | £13 | £14 | £15 | £16 |
| Approximate weight .. cwts. | 53 | 61 | 74 | 84 | 92 | 95 | 126 | 134 |
| Ditto measurement cubic ft. | 208 | 256 | 285 | 334 | 349 | 390 | 457 | 501 |

The cost of packing for shipment and delivery f.o.b is about 5 per cent.

**PETROLEUM BURNING PORTABLE ENGINES** are highly economical where petroleum oils abound and other fuels, (as is usually the case) are expensive.

The engine is constructed as shown in Fig. 1512, excepting that the fire box is made of extra dimensions, to ensure complete combustion and to avoid injury to the fire box and boiler tubes; the petroleum oil fuel is supplied from a tank which forms part of the equipment and the engine is complete with fittings and connections between the tank and fire box.

The fire box is easily arranged for working with any fuel in ordinary use and the prices of additions and accessories and the weights and measurements are about the same as for the engines Fig. 1512.

PRICES OF DOUBLE CYLINDER PETROLEUM BURNING ENGINES.

| Nominal horse power .. .. .. | 10 | 12 | 16 | 20 |
|---|---|---|---|---|
| Price of engine .. .. .. .. | £300 | £345 | £425 | £510 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

PRICES OF SINGLE CYLINDER PETROLEUM BURNING ENGINES.

| Nominal horse power .. .. .. | 4 | 6 | 8 | 10 | 12 |
|---|---|---|---|---|---|
| Price of engine .. .. .. .. | £170 | £205 | £240 | £275 | £320 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**STRAW BURNING PORTABLE ENGINES.**—A trough with automatic feed apparatus worked from the engine, is fixed in front of the fire door of the boiler as usually constructed, and projects the fuel into the fire box, in a manner which ensures perfect combustion.

This invaluable invention admits of the use for firing, of straw, cotton or maize stalks, megass, reeds, brushwood, small branches, &c, in lieu of coal. If straw is used, the consumption is (in weight) about 3 or 4 times that of coal.

The refuse burning appliances are quite easily removed and the boiler fired with coal or wood in the usual manner. The engines are fitted and finished in the manner indicated in Fig. 1512 and the extra cost of automatic expansion gear worked from the governors and other additions, will be found in the list relating to those engines.

PRICES OF DOUBLE CYLINDER STRAW BURNING ENGINES.

| Nominal horse power .. .. | 8 | 10 | 12 | 16 | 20 |
|---|---|---|---|---|---|
| Price of engine .. .. .. | £275 | £310 | £350 | £425 | £510 |

PRICES OF SINGLE CYLINDER STRAW BURNING ENGINES.

| Nominal horse power .. .. | 5 | 6 | 8 | 10 | 12 |
|---|---|---|---|---|---|
| Price of engine .. .. .. | £205 | £220 | £250 | £285 | £325 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**MARINE ENGINES AND BOILERS** vary so widely in type and dimensions that only a few can be tabulated, treble and quadruple expansion engines and others not mentioned being left for special design and estimate. The principles, however, involved in the design and construction of all machinery of this kind, and carefully observed in that referred to are, that it shall be capable of developing a maximum power with a minimum total weight, that the consumption of fuel shall be as low as possible and that the working parts shall be of ample strength, and arranged to admit of the free access to them, requisite for efficient maintenance.

To obtain these results and sustained efficiency—which means true economy to the purchaser—the materials used must be the best of their respective kinds and carefully finished and adjusted, points which are steadily kept in view in the design and construction of the machinery referred to in the following pages.

Boilers of different types are illustrated and described at p.p. 36 to 38 but for the convenience of purchasers who may not possess information as to the proportions of boilers requisite for the various sizes of engines, the approximate prices of these are given and of propellor machinery as usually required.

The machinery is constructed and fitted in accordance with Board of Trade regulations, or under Lloyd's inspection provided that the fees, at Lloyd's scale, are paid by the purchaser. These vary in amount but are never a serious item.

**YACHT ENGINES AND BOILERS** to develop high powers with minimum space and weight, are specially designed to suit requisite conditions in regard to power, distribution of weight, &c., and prices for them will be furnished when these conditions have been considered.

**COMPOUND SURFACE CONDENSING ENGINES** illustrated by Fig. 1513 are entirely self-contained; the surface condenser is carried on an extension of the bed plate, and all parts are completely accessible for examination.

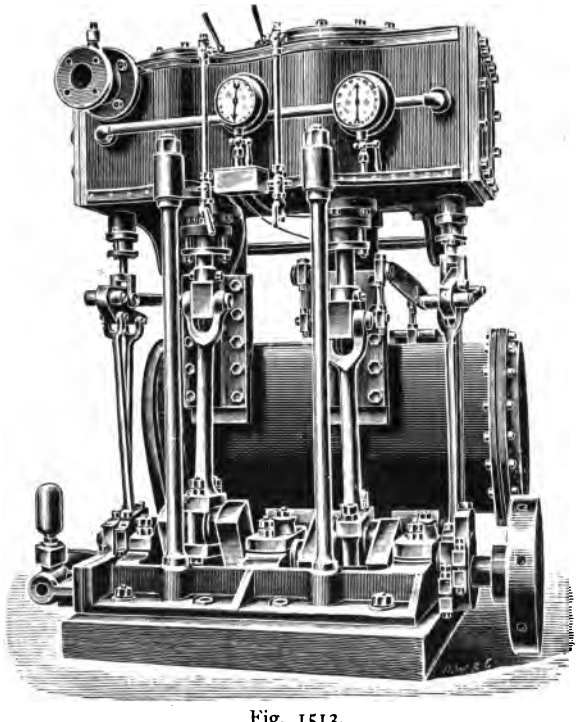


Fig. 1513.

**The engines.**—The high and low pressure cylinders are separate and fitted with gun metal valves, outside valve covers planed and scraped and the cylinders are encased in polished teak, secured by brass bands. The crank shaft, motion work and connecting rods are of forged mild steel finished bright and accurately adjusted and provided with the necessary lubricators, &c. The link motion reversing gear is thoroughly case hardened and is worked by a hand wheel, with appliances for maintaining it in the position to give the point of cut off desired. The engines are mounted on a massive and strongly ribbed bed plate which carries the forged bright wrought iron columns supporting the cylinders, the bearings for the crank shaft which have large wearing surfaces, and the surface condenser.

**The condenser** is fitted with brass tube plates and solid drawn brass tubes with screwed glands, the covers, as will be seen, are easily removed and quite accessible for examination. The air and circulating pumps are lined with brass and have gun metal buckets, valve seats and guards; the feed pump is provided with an air vessel and this, as well as the bilge pump, has brass plunger and gland.

**The Boilers** are of the well known marine type (see Fig. 1532) tested by hydraulic pressure to 150 lbs. per square inch, of ample proportions and complete with the usual furnace, steam, exhaust and feed water fittings, smoke box and funnel.

**The pipe connections** between the boiler and engines and to sea are of copper, with brass flanges and bolts and gun metal valves; the bilge pipes are of lead.

**The propeller gear** consists of forged steel shafting with couplings and turned bolts, propeller shaft sheathed with brass, cast iron propeller, stern tube with brass bushed gland and long brass neck; the outer end bushed with brass and fitted with lignum vitæ bearings and large gun metal thrust bearing.

For the extra cost of construction under Lloyds' inspection see remarks at page

PRICES OF COMPOUND CONDENSING MARINE ENGINES, Fig. 1513.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nominal horse power .. .. | 6 | 8 | 10 | 15 | 16 | 20 | 25 | 30 |
| Diameter of H.P. cylinder ins. | 6 | 7 | 8 | 9 | 10 | 11 | 12½ | 14 |
| Ditto L.P. ditto ,, | 12 | 14 | 15 | 18 | 20 | 22 | 22 | 26 |
| Stroke of piston .. ,, | 7½ | 9 | 10 | 12 | 14 | 16 | 18 | 18 |
| Price of engine .. .. .. | £200 | £250 | £280 | £355 | £385 | £465 | £520 | £660 |
| Ditto propeller gear .. .. | £30 | £35 | £40 | £48 | £58 | £68 | £75 | £85 |
| Ditto of boiler .. .. | £95 | £120 | £145 | £175 | £190 | £245 | £330 | £430 |
| Ditto copper connections .. | £20 | £30 | £40 | £50 | £65 | £75 | £85 | £100 |
| Ditto donkey pump, pipes,&c. | £20 | £30 | £40 | £50 | £65 | £75 | £95 | £100 |
| Ditto gun metal propeller, extra | £10 | £12 | £15 | £20 | £30 | £40 | £50 | £60 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

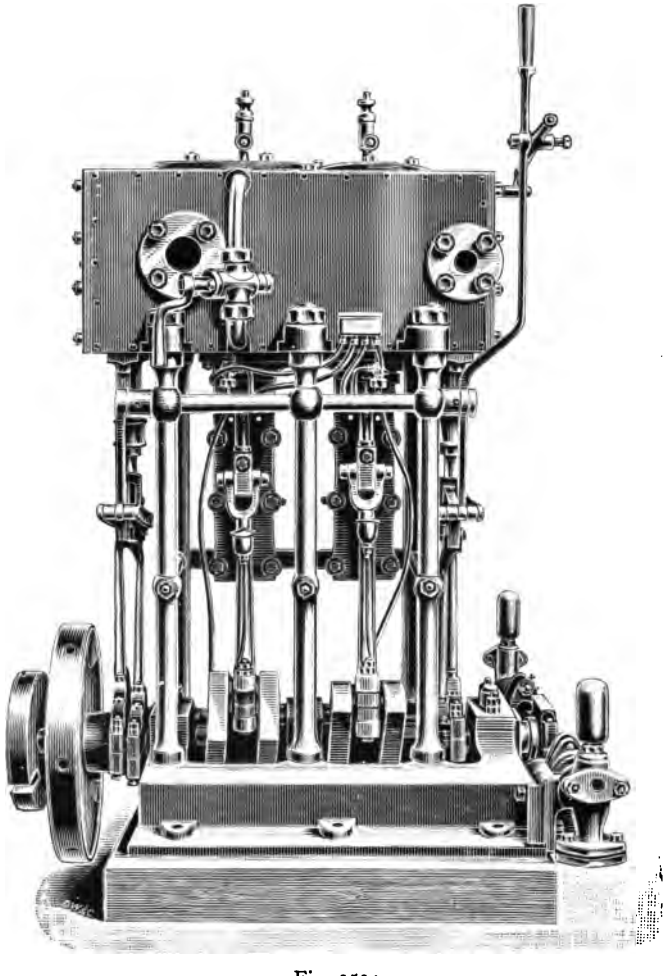


Fig. 1514.

**DOUBLE CYLINDER NON-CONDENSING SCREW PROPELLER ENGINES** illustrated by Fig. 1514, have steam cylinders of equal dimensions and are not provided with condenser and fittings and, as they are fitted and finished in the same manner as those last described, it will be unnecessary to repeat the detailed description which accompanies Fig. 1513.

**The boilers** are of the Marine type shown in Fig. 1515 and the external dimensions are tabulated so that purchasers may determine, without enquiry, whether they have the space requisite for a boiler of that construction, or whether one of the locomotive, or some other type will be more convenient.

If a locomotive boiler is supplied the cost will be about 10 per cent less than that of a Marine boiler of equal power.

**The propeller gear** comprises the usual length of bright steel shaft with couplings, &c., cast iron propeller, brass bushed, cast iron stern tube and brass thrust bearings.

The prices of pipes and other accessories are the same as those for engines of equal power of the type Fig. 1513.

PRICES OF DOUBLE CYLINDER NON-CONDENSING ENGINES, Fig. 1514.

| | | | | | | |
|---|---|---|---|---|---|---|
| Nominal horse power .. .. | 6 | 8 | 10 | 14 | 18 | 24 |
| Diameter of cylinders .. inches | 5 | 6 | 7 | 8 | 9 | 10 |
| Stroke of piston .. ,, | 7 | 7 | 8 | 9 | 10 | 10 |
| Price of engine .. .. .. | £74 | £98 | £125 | £170 | £185 | £215 |
| Ditto extra feed pump extra | £5 | £6 | £7 | £8 | £10 | £12 |
| Ditto boiler with fittings ,, | £95 | £112 | £143 | £165 | £190 | £245 |
| Diameter of boiler .. feet | 4 | 4½ | 5 | 5½ | 6 | 6½ |
| Length ditto .. ,, | 6 | 6½ | 6½ | 7 | 7½ | 8 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

PRICES OF SINGLE CYLINDER ENGINES, TYPE Fig. 1514.

| | | | | | | |
|---|---|---|---|---|---|---|
| Nominal horse power .. .. | 3 | 4 | 5 | 7 | 9 | 12 |
| Diameter of cylinder .. inches | 5 | 6 | 7 | 8 | 9 | 10 |
| Stroke of piston .. ,, | 7 | 7 | 8 | 9 | 10 | 10 |
| Price of engine .. .. .. | £42 | £54 | £68 | £94 | £100 | £116 |
| Ditto propeller gear & copper pipe | £25 | £28 | £35 | £40 | £47 | £55 |
| Ditto boiler with fittings extra | £80 | £86 | £92 | £105 | £144 | £158 |
| Diameter of boiler .. feet | 3 | 3 | 4 | 4½ | 4¾ | 5 |
| Length ditto .. ,, | 3½ | 4 | 5½ | 6 | 6½ | 7 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

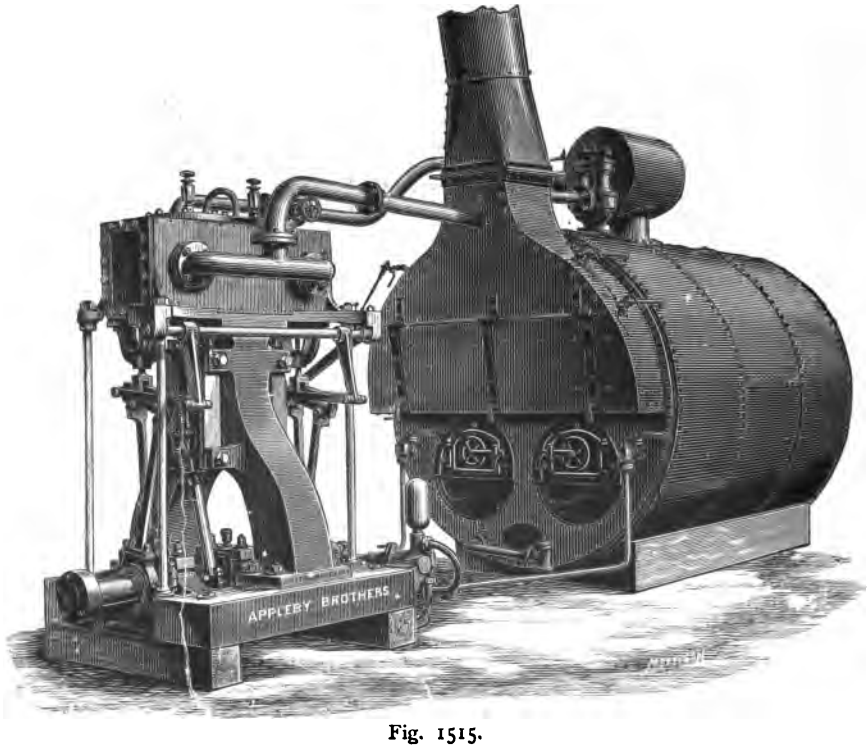



Fig. 1515.

**DOUBLE CYLINDER SCREW PROPELLER ENGINES.**—The arrangement indicated in Fig. 1515 has been largely and successfully used for commercial purposes and more especially for tug boats, referred to in detail in Section V.

The weights of these engines necessarily exceed those of the type Fig. 1514, but the more massive construction is sometimes deemed an advantage in machinery for tug boats, &c. If fresh water only is used, a boiler of the locomotive type may be preferred, the cost of which, complete with furnace, steam, exhaust and feed water fittings, is about 10 per cent. less than that of the boiler of marine type shown in the engraving.

The prices of double and single cylinder engines, of this construction, are practically the same as those given for Fig. 1514. The prices of accessories will be found by reference to these tables and to that relating to Fig. 1513.

# STEAM BOILERS.

**LANCASHIRE AND CORNISH BOILERS.**—Ample experience has demonstrated that these internally fired boilers are completely satisfactory where a constant supply of steam is required, at pressures not exceeding 150 lbs. per square inch, and where brickwork setting can be provided.

The areas of the fire grates can be arranged to give the highest efficiency, whatever kind of fuel may be most economical in point of cost, and both types are quite accessible for examination, cleaning, &c.; but in all large works there should be at least one boiler, in each range or group, to lay off for the periodical examination which should be rigidly enforced and strictly carried out.

**The Lancashire boiler** with its two flues and two furnaces possesses advantages where high pressures and a large supply of steam must be maintained. The flue tubes form good stays for the flat ends and, if the furnaces are alternately stoked at proper intervals, the hot gases from one furnace consume the thick smoke emerging from that which has just been stoked and so tends to prevent the escape of unconsumed products in the form of black smoke and maintains a more even temperature in the boiler.

**The Cornish boiler** having only one flue may—to that extent—be regarded as more simple in construction than the Lancashire boiler which has two flues, but there is so little difference in this respect, or in durability, that the selection of the type to be adopted is influenced more by considerations as to the power and working pressure required, the space available and similar details, than by questions of construction.

**Nominal and Indicated horse power.**—The former term is retained (as mentioned at page 3) for the convenience of those who have been accustomed to use it, but the capacity in "Indicated horse power" is added to save the trouble of calculation to those who prefer this more modern and much more accurate definition which is based on the evaporation of 20 lbs. of water for each indicated horse power per hour, and due allowance should be made if the fuel used is of inferior quality.

**Testing and delivery.**—The usual course is to test every boiler before it leaves the Works to nearly double the working pressure, but in some cases it is more economical and convenient to adopt the undernamed arrangement.

**Rivetting at destination.**—Where difficulties in transport are formidable, parts of the boilers are rivetted up and the work is completed at the site where they are to be used. But more frequently the plates and other parts are drilled in place and carefully marked and sent out in this state, with an ample supply of rivets, tools, &c. When this course has been adopted, great outlay in freight and inland transport charges has been saved, and there has never been any difficulty in re-assembling the parts and satisfactorily completing the work at destination. In many cases it has been necessary to send out skilled rivetters but—even including this expense—there has almost always been a saving in total cost and much inconvenience has been avoided.

**LANCASHIRE BOILERS** illustrated by Fig. 1521 are constructed as follows, unless otherwise specified, and the prices of the standard sizes will be found in the following tables. It will however be understood that if boilers of other dimensions are required they will be specially built; the cost will be about the same as that of a standard boiler of equal capacity.

**The shell** is made of Siemens—Martin mild steel of boiler quality and, as far as possible, each ring is formed of a single plate. The edges of all plates are planed and—for working pressures exceeding 70 lbs. per square inch—the longitudinal seams are butt jointed with double cover strips secured by six lines of rivets; the circular seams are lap-jointed and double rivetted.

**The flues** are made of fire-box steel, the longitudinal seams are welded, the cross tubes are welded in the flue tube and all flanging is done by machine.

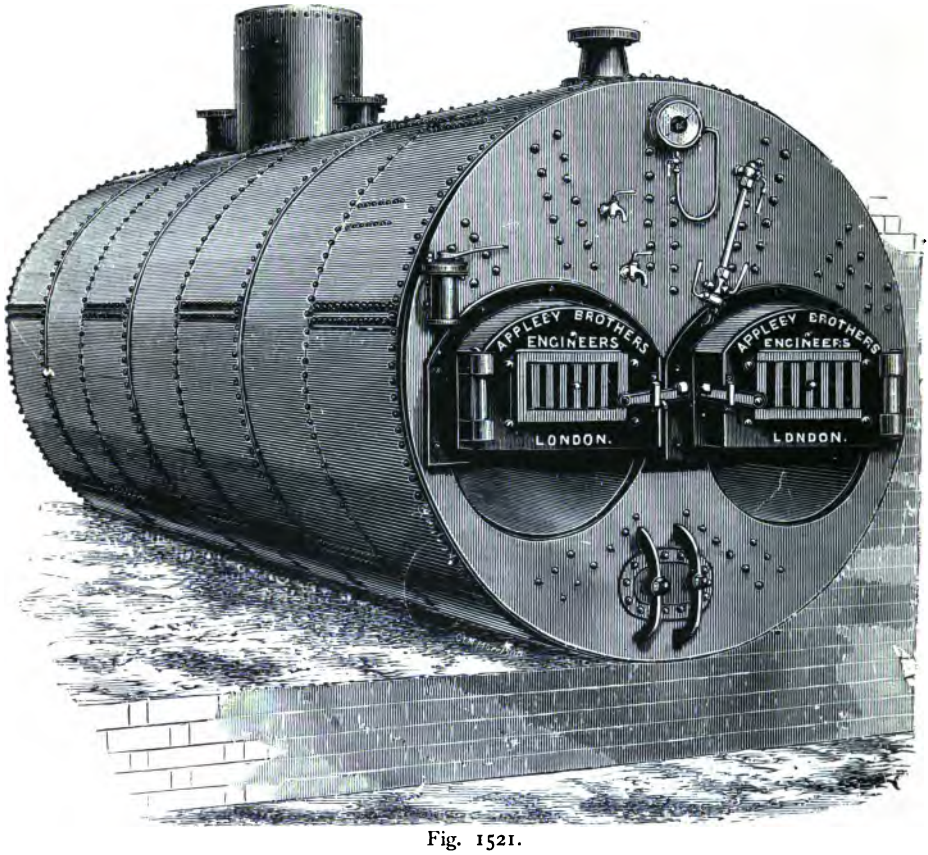



Fig. 1521.

**End plates.**—The back end plate is flanged and the front plate is connected to the shell by an external angle iron ring; both ends are provided with suitable stays and each is formed of a single plate.

**Flanging, drilling, rivetting, &c.**—All flanging and rivetting is done by machine and the rivet holes are drilled in place.

**The furnace fittings** include the furnace fronts with perforated doors, regulators and fastenings, fire grates, soot doors, damper, chain and counterweight.

**The steam fittings** consist of a steam stop valve with anti-priming pipe, dead weight safety valve, high steam and low water safety valve, check feed valve with internal pipe, gun metal blow-off cock, steel bend pipe, gun metal asbestos packed water gauges, water level indicator and dial steam pressure gauge, with syphon, marked to indicate lbs. per square inch, or atmospheres, or both if desired.

**Testing.**—All boilers referred to in the following list are submitted to the standard test, by hydraulic pressure, of $1\frac{3}{4}$ times the maximum working pressure.

**Indicated horse power.**—As already stated, this is calculated on the evaporation of 20 pounds of water per hour for each I.H.P.

**Setting.**—If desired, drawings will be supplied, free of cost, showing the setting in detail. If there is any difficulty in obtaining fire bricks, quoins and other special bricks, fire clay, &c., these will be supplied at the current prices of the day.

**The steam dome** shown in Fig. 1521 is now rarely required and is not included in either price or shipping measurement. An internal collecting pipe is generally used in lieu of the dome.

PRICES OF LANCASHIRE BOILERS, FIG. 1521 FOR 100 LBS. PRESSURE.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nominal horse power.. .. | 30 | 35 | 40 | 50 | 60 | 70 | 80 | 100 |
| Approximate I.H.P. .. .. | 150 | 175 | 200 | 250 | 300 | 325 | 350 | 400 |
| Length .. .. .. feet | 20 | 22 | 24 | 28 | 28 | 28 | 30 | 30 |
| Diameter .. .. ,, | 6 | 6½ | 6½ | 7 | 7½ | 8 | 8 | 8½ |
| Ditto of flues .. inches | 27 | 28½ | 30 | 33 | 36 | 38½ | 38½ | 41 |
| Number of cross tubes .. | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| Price of boiler and fittings .. | £230 | £255 | £270 | £325 | £360 | £385 | £400 | £460 |
| Approx. measurement cub. feet | 845 | 1000 | 1176 | 1575 | 1790 | 2070 | 2220 | 2775 |

The cost of packing for shipment and delivery f.o.b. is usually about 5 per cent.

**LANCASHIRE BOILERS for 150 lbs. PRESSURE.**—As the standard dimensions given in the foregoing list are adhered to it will only be necessary to give the approximate I.H.P. developed at this pressure and the prices of the boilers. The test pressure is 250 lbs. per square inch.

PRICES OF LANCASHIRE BOILERS, FIG. 1521 FOR 150 LBS. PRESSURE.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Approximate I.H.P. .. .. | 165 | 190 | 220 | 275 | 330 | 360 | 385 | 440 |
| Price of boiler and fittings .. | £307 | £340 | £360 | £433 | £480 | £513 | £533 | £580 |

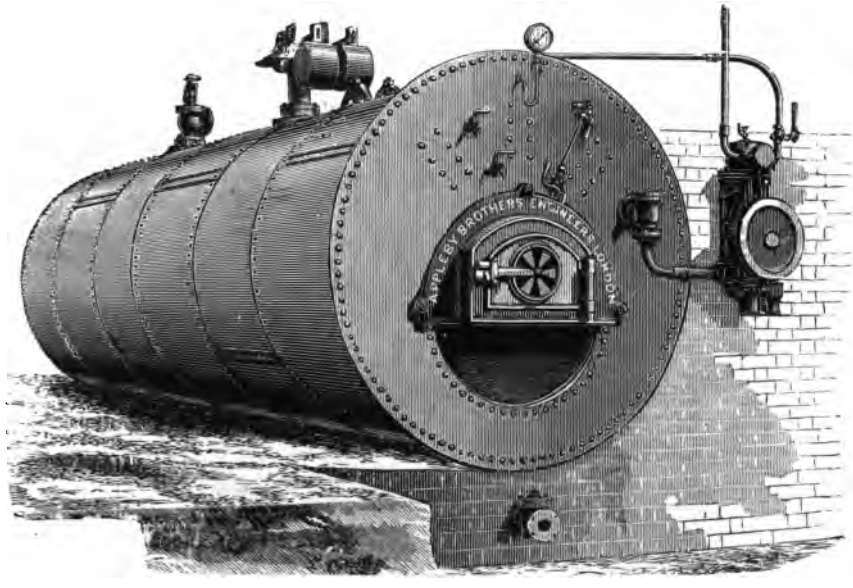



Fig. 1522.

**CORNISH BOILERS,** Fig. 1522.—The construction, quality of materials, fittings, etc., being similar to those used for the Lancashire boilers last referred to, it will suffice to give the subjoined prices for the standard sizes and powers, as usually made. As indicated at page 3, the approximate I.H.P. is in all cases based on a consumption of 20 lbs. of steam per indicated horse power per hour.

PRICES OF CORNISH BOILERS, Fig. 1522.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal horse power .. | 6 | 8 | 10 | 12 | 14 | 16 | 20 | 25 | 30 |
| Approximate I.H.P. .. .. | 30 | 40 | 50 | 60 | 70 | 80 | 100 | 125 | 150 |
| Length .. .. .. feet | 10 | 12 | 14 | 15 | 16 | 17 | 19 | 22 | 24 |
| Diameter .. ... ,, | 4 | 4 | 4¼ | 4½ | 4¾ | 5 | 5⅓ | 5½ | 6 |
| Ditto of flues .. inches | 24 | 24 | 26 | 27 | 30 | 33 | 34 | 36 | 38½ |
| Number of cross tubes .. | .. | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 |
| Price for 80 lbs. pressure .. | £74 | £84 | £98 | £112 | £120 | £140 | £155 | £173 | £190 |
| Ditto 100 lbs. do. .. | £77 | £88 | £103 | £118 | £126 | £148 | £162 | £180 | £200 |
| Approx. measurement cub. ft. | 200 | 245 | 300 | 375 | 440 | 510 | 670 | 800 | 1045 |

The cost of packing for shipment and delivery f.o.b. is usually about 5 per cent.

Fig. 1523.

**CROSS TUBES FOR BOILERS** (Fig. 1523) serve the double purpose of strengthening the flue, and increases both the rapidity of circulation and the heating surface. The diameter just under the top flange being greater than the diameter of the other end of the tube, induces the more rapid circulation of the water and at the same time renders them easy of application to existing boilers. The prices of the tubes are as follows :—

Not exceeding 2ft. 6in. long, £1 15 0 each.
,, 3ft. 0in. ,, £2 0 0 ,,
,, 3ft. 6in. ,, £2 5 0 ,,
,, 4ft. 0in. ,, £2 10 0 ,,

The cost of tubes with rivet holes punched is 2s. per tube extra.

The exact internal and external diameter of the flue to be fitted, and the number of tubes, or length of the flue, and a sketch showing the length of each plate in the flue, should be furnished when tubes are required to be fitted to an existing boiler.

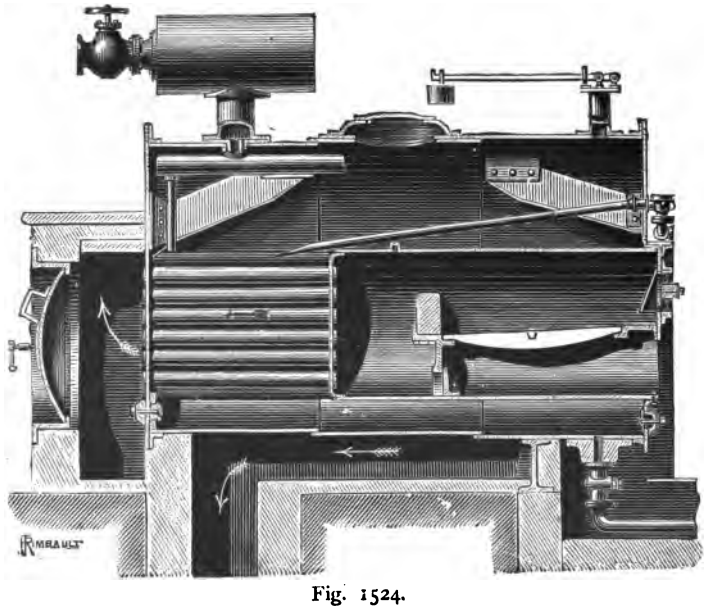


Fig. 1524.

**SEMI-MULTITUBULAR BOILERS** of the construction indicated in Fig. 1524 are perfectly accessible for inspection and cleaning and, being entirely self contained, the setting is of the simplest character; those now referred to are for a working pressure of 80 lbs. per square inch but they are built for higher pressures, or with corrugated flues, if desired.

The boilers are made of Siemen's mild steel plates flanged and rivetted by hydraulic machines; the fire grate is in the front part of the flue exactly as in a Cornish boiler and the gases pass in the direction shown by the arrows, firstly through the nest of tubes at the end of firebox, and subsequently through the combustion chamber around each side, and finally through the flue under the boiler, to the chimney as shown.

The internal heating surface is about 18 square feet per nominal horse power, to which must be added the 3 square feet, or more, per nominal horse power, of heating surface obtained from contact with the shell plates in the side flues.

The following prices include all usual fittings such as the furnace front with door, air regulator and baffle plate, dead plate, fire bars and bearers. The steam fittings comprise a safety valve, stop valve, feed valve and blow off cock with seatings rivetted to the boiler; also a set of water gauge fittings, gauge cocks, fusible plug and anti-priming pipe. The steam collecting drum shown in the engraving is frequently sent loose for rivetting at destination, to save cost in freight.

PRICES OF SEMI-MULTITUBULAR BOILERS, Fig. 1524.

| Nominal horse power .. | 8 | 12 | 16 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|
| Length of boiler .. .. | 6ft. 7in. | 7ft. 8in. | 8ft. 2in. | 8ft. 9in. | 9ft. 8in. | 12ft. 8in. | 13ft. 3in. |
| Diameter do. .. .. | 4ft. | 4ft. 8in. | 5ft. 4in. | 5ft. 10in. | 7ft. | 7ft. 6in. | 8ft. 9in. |
| Price with fittings .. | £90 | £135 | £165 | £200 | £285 | £360 | £450 |

The cost of packing for shipment and delivery f.o.b. is usually about 5 per cent.

**FURNACES FOR MEGASS, RICE, SAW MILL** and other refuse. Most fibrous matter has some value as fuel if it is used in properly constructed furnaces, and much that formerly was allowed to pollute and choke rivers, or was a source of expense for removal, is now used (especially in the East) with great economy in wholly—or to a great extent—dispensing with coal or other fuel.

Proprietors are usually indebted for the designs for such furnaces, to their engineers who are necessarily familiar with the calorific value of the refuse; but if assistance in designing furnaces for this purpose should be desired, it will be furnished provided that the necessary data is given with regard to the matter to be utilised.

Fig. 1525.

**UNDER-FIRED MULTITUBULAR BOILERS** as represented in Fig. 1525, are largely used in Sugar and other factories where waste products such as megass, wood, &c., are available as fuel, the large furnaces with which they are provided rendering them specially suitable for the purpose.

The shells are constructed of mild steel and the longitudinal seams are double rivetted, the ends are each formed of one plate and are stayed by wrought iron bolts. Boilers up to 60 horse power have a large steam dome which is removed for transport and arranged to be bolted in place on arrival at destination. Those of higher power have a horizontal steam reservoir, which is also removed for transport and secured to the seatings, by bolts, as shown. If desired, a wrought iron shoot for firing with megass is sent at a small extra cost.

The fittings, and the mode of fixing them on stools rivetted to the boiler, are in accordance with the best practice and consist of steam stop valve with branch, double safety valve, low water detector, dial steam pressure gauge, a set of water gauges, trial cocks, feed and retention valve and dip pipe ; a gun metal blow-off cock is fixed to the bottom of the boiler, and bolts and girders for suspending boilers of 45 horse power and upwards are provided. The furnace fittings comprise large fire door and frame, smoke box door and frame, damper and frame, fire bars and girders for brick work. The subjoined prices include 10 per cent. of spare steam tubes, 10 per cent of fire bars, spare gauge glasses, tube scraper or brushes, &c.

The circulating tubes, being subject to the same temperature as the combustion chamber, materially increase the steaming power and efficiency of the boiler, and are well worth the small amount they cost.

Each boiler is tested by hydraulic pressure to 120 lbs. per square inch, and ample heating surface is provided for evaporating 60 lbs. of water for each horse power.

PRICES OF UNDER-FIRED BOILERS, Fig. 1525.

| Nominal horse power .. .. | 45 | 50 | 60 | 70 | 85 | 100 | 120 | 130 |
|---|---|---|---|---|---|---|---|---|
| Length of boiler .. .. | 11ft. | 12ft. | 12ft. | 12ft. | 14ft. | 14ft. | 14ft. | 15ft. |
| Diameter of boiler .. .. | 6ft. | 6ft. | 6ft.6in. | 7ft. | 7ft. | 7ft.6in. | 8ft. | 8ft. |
| Number of tubes 4in. ex. diam. | 66 | 66 | 80 | 96 | 96 | 118 | 136 | 136 |
| Price of boiler and fittings .. | £275 | £288 | £345 | £385 | £415 | £460 | £518 | £556 |
| Extra for circulating tubes .. | £15 | £15 | £18 | £20 | £20 | £22 | £24 | £24 |

The cost of packing for shipment and delivery f.o.b. varies from 4 to 6 per cent.

The boilers referred to in the following lists are of the type Fig. 1525, but are without the horizontal steam reservoir and the proportions are modified to adapt them for long or short flame fuel. They are constructed for a working pressure of 80 lbs. per square inch and are complete with furnace and steam mountings. If the working pressure is 100 lbs. per square inch the extra cost averages about 20 per cent.

PRICES OF HORIZONTAL MULTITUBULAR BOILERS, FIRED EXTERNALLY.

| Nominal horse power .. .. | 6 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|
| Length .. .. .. .. | 7ft. 6in. | 9ft. | 10ft. | 10ft.6in. | 11ft. | 11ft. |
| Diameter .. .. .. .. | 2ft. 6in. | 2ft. 9in. | 2ft.11in. | 3ft. | 3ft. 6in. | 3ft.10in. |
| Number of tubes .. .. | 20 | 22 | 25 | 28 | 32 | 38 |
| Price of boiler and fittings .. | £49 | £56 | £70 | £75 | £86 | £104 |
| Approximate weight .. tons | 1¼ | 1½ | 1¾ | 2 | 2¼ | 3 |
| ,, meas. in cubic feet .. | 70 | 100 | 130 | 150 | 190 | 215 |

| Nominal horse power .. .. | 18 | 20 | 25 | 30 | 35 | 40 |
|---|---|---|---|---|---|---|
| Length .. .. .. .. | 12ft. | 12ft. | 12ft. | 12ft.6in. | 13ft. | 14ft. |
| Diameter .. .. .. .. | 3ft. 10in. | 4ft. 2in. | 5ft. | 5ft. 6in. | 6ft. | 6ft. |
| Number of tubes .. .. | 38 | 42 | 54 | 60 | 70 | 74 |
| Price of boiler and fittings .. | £108 | £125 | £152 | £178 | £206 | £230 |
| Approximate weight .. .. | 3½ | 3½ | 4½ | 5 | 6½ | 7 |
| ,, meas. in cubic feet .. | 220 | 240 | 360 | 470 | 550 | 650 |

The cost of packing for shipment and delivery f.o.b. is 3 per cent.

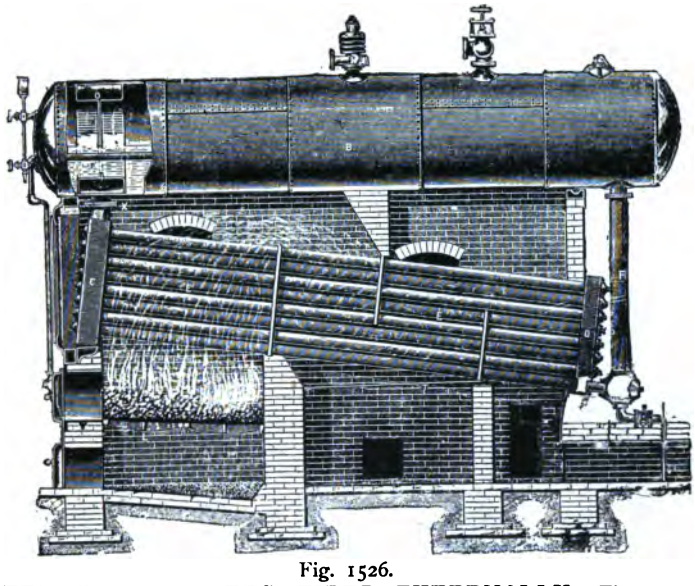


Fig. 1526.

**WATER TUBE BOILERS FIRED EXTERNALLY.**—The construction is clearly shown in the engraving Fig. 1526 and the following short description will indicate that boilers of this type may be fired with ordinary or anthracite coal, and are easily adapted to work with inferior fuels. Amongst these may be mentioned megass, wood, vegetable fibres, dried tan, town refuse, or with the waste gases from furnaces, &c.

The separate parts are light and are easily transported, and no difficulty has been experienced in having them re-erected and set to work by local mechanics.

The tubes are usually made of wrought iron, and at each end are connected to circulating boxes made of rolled steel plates and fitted with a steel cover opposite each tube. The upper circulating box conveys the steam to the steam reservoir, and the lower end is connected with a box through which any dirt or condensed steam is carried to the blow-off cock. Ample provision is made for contraction and expansion, without affecting the joints, and the steam is conveyed from the generating tubes into a separator with openings. so arranged that no disturbance is created in the reservoir, and a supply of dried steam is maintained.

The usual working pressure is 120 lbs. per square inch, the capacity of the boiler is based on an allowance of about 11½ square feet of heating surface for each boiler horse power.

The approximate measurements are for the sections taken apart and packed to economise space. If the boiler is sent out complete these measurements are largely exceeded.

The following prices include all fittings, as shown, and the spaces occupied are those when the boiler is set in brickwork.

PRICES OF WATER TUBE BOILERS, Fig. 1526.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Horse-power of boiler .. .. | 20 | 30 | 40 | 75 | 100 | 150 |
| Space occupied, length .. .. | 13ft. 6in. | 15ft. 6in. | 18ft. oin. | 18ft. oin. | 21ft. oin. | 22ft. oin. |
| ,, ,, width .. .. | 4ft. 6in. | 5ft. oin. | 5ft. 8in. | 6ft. 4in. | 6ft. 4in. | 8ft. 4in. |
| Price of boiler .. .. .. | £148 | £193 | £228 | £347 | £443 | £636 |
| Approx. weight .. .. tons | 4 | 6 | 7 | 10¼ | 12 | 17 |
| ,, measurement cubic feet | 5½ | 8 | 9½ | 13 | 15½ | 23 |

The cost of packing for shipment and delivery f.o.b. varies according to destination, but, for purposes of estimate, it may be assumed to be about 5 per cent.

A modification of this type of boiler consists in adding a water-cased furnace in lieu of the direct firing indicated in Fig. 1526. The efficiency of this boiler under test has been nearly 11 lbs. of water evaporated per lb. of coal used. In another set of trials extending over nine days, with inferior coal, the average evaporation was more than 9½ lbs. of water per lb. of coal, whilst with water-tube boilers of different construction, tested at the same time, the evaporation was less than 7 lbs. of water evaporated per pound of coal used.

Prices of boilers with water cased furnaces will be sent on application.

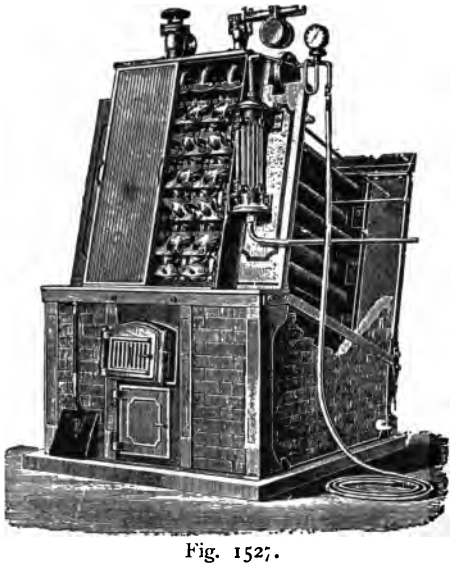


Fig. 1527.

**SECTIONAL BOILERS.**—Fig. 1527 illustrates one of many combinations whereby boilers of this construction may be arranged to suit almost any available site.

The boiler consists of a number of steel tubes, each of very moderate weight, arranged in groups of the number and dimensions requisite for supplying a given volume of steam. These tubes are connected by metallic joints, which are practically imperishable, and are fixed at the angle necessary for the steam —which is rapidly generated by the flame and gases enveloping the tubes externally—to rise freely to the steam receiver, whence it passes to the engines

Boilers of this type are intended for high pressures and are tested to not less than 300 lbs. per square inch, and, as this so far exceeds the pressure in general use with boilers of other types, it is considered desirable to state the number of square feet of heating surface as well as the nominal horse power which is given in other cases.

The cost of transport for bulky and heavy packages, such as boilers of the Cornish or locomotive type, frequently far exceeds that of the boiler delivered at a foreign port, whilst an equal weight in a number of relatively light packages, can be conveyed at a comparatively low rate. Under these circumstances, the construction above referred to has everything to recommend it and, especially so if a high working pressure and economy in consumption of fuel are regarded as essential.

PRICES FOR SECTIONAL BOILERS, FIG. 1527, AND ACCESSORIES.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal horse power .. .. | 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 |
| Heating surface in square feet .. | 60 | 120 | 180 | 240 | 300 | 360 | 480 | 600 | 720 |
| Price of boiler and fittings .. .. | £80 | £120 | £165 | £205 | £240 | £270 | £320 | £365 | £405 |
| ,, steam feed pump & connections | £16 | £18 | £18 | £22 | £24 | £27 | £30 | £32 | £35 |
| Price of injector .. .. .. | £10 | £12 | £15 | £17 | £22 | £24 | £26 | £28 | £30 |
| ,, feed water heater .. .. | £25 | £28 | £30 | £32 | £35 | £35 | £40 | £45 | £50 |
| ,, water purifier .. .. | .. | £15 | £20 | £25 | £30 | £35 | £45 | £55 | £60 |
| ,, iron casing .. .. .. | £32 | £36 | £39 | £45 | £49 | £54 | £60 | £71 | £82 |
| ,, wrought iron chimney .. | £20 | £22 | £26 | £31 | £39 | £46 | £52 | £61 | £68 |
| ,, mechanical stoker .. .. | £30 | £32 | £35 | £36 | £40 | £50 | £70 | £97 | £128 |
| Approximate weight of boiler and fittings, .. .. tons | 3¾ | 4½ | 5¼ | 6 | 7 | 8¼ | 10½ | 12½ | 15 |
| ,, meas. of do. in cubic feet.. | 200 | 250 | 300 | 330 | 350 | 400 | 460 | 510 | 610 |
| ,, weight iron casing, in tons | 2 | 2½ | 2¾ | 3 | 3¼ | 3½ | 4 | 4¾ | 5½ |
| ,, meas. of do. in cubic feet.. | 80 | 100 | 110 | 120 | 130 | 140 | 160 | 190 | 220 |
| ,, weight of wrought iron chimney .. .. cwts. | 8 | 10 | 12 | 13 | 15 | 18 | 23 | 28 | 34 |
| ,, meas. of do. in cubic feet.. | 32 | 40 | 45 | 50 | 55 | 65 | 85 | 100 | 120 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

These boilers may be set in brickwork, as shown in the engraving, but iron casings, the cost of which will be found above, are frequently adopted and are recommended. Some of the fittings and accessories differ in some respects from those generally used, and for this reason they are briefly described.

**The prices for boilers** include grate bars and all usual furnace and steam fittings, and those for mechanical stokers are for the apparatus complete, excepting the motive power for working it.

**The feed pump, or injector,** or both, will be sent out complete with the valves and pipes required for connection with the boiler.

**The feedwater heater** is arranged to utilise the waste heat from the boiler, and the subjoined prices include the pipe connection and valves requisite for passing the water through the heater, or not, at pleasure.

**Water Purifiers** may be arranged in connection with the steam receiver and are invaluable whenever good feed water cannot be readily obtained.

**The Chimneys** are constructed of wrought iron with strong cast iron base plate, stays, and attachments for them, but fire bricks for lining &c., are not included in the price; these will be supplied if desired.

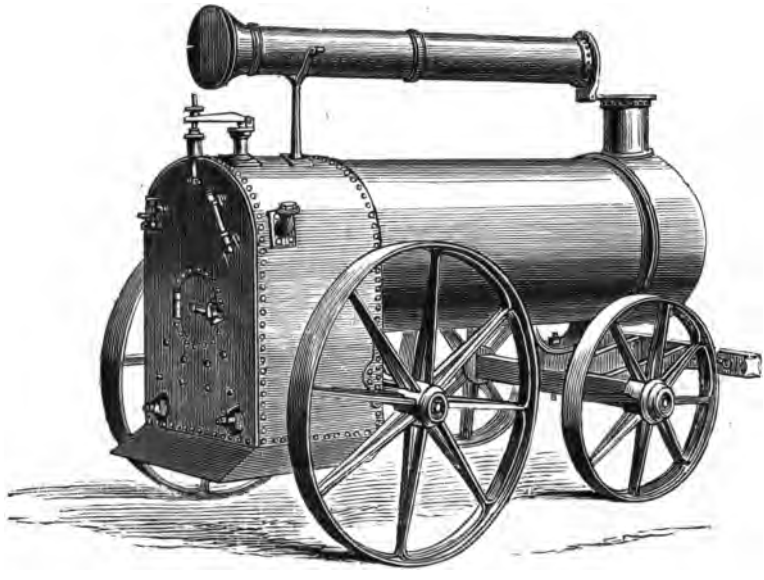


Fig. 1528.

**LOCOMOTIVE MULTITUBULAR BOILERS** of the type Fig. 1528, are (unless otherwise specified) constructed for a working pressure of 80 lbs. to the square inch, and are tested to about double that pressure; the cost naturally varies according to the pressure required, but all boilers comply with Board of Trade Regulations if so required.

The shells are usually made of steel, and the internal firebox of Lowmoor or Bowling Iron. The steam fittings quoted separately, consist of a dial pressure gauge marked to 100 lbs. per square inch, safety valve, stop valve, feed valve, glass water gauge and cocks, gauge cocks, and blow off cock.

The following list gives the prices of fixed boilers suitable for the working pressure above named, with and without ash pan, pedestal support for smoke box end and fittings, also for lagging, felting and covering with sheet iron, and the extra cost of mounting it on axles with timber or wrought iron wheels. For extra large fire boxes add £1 per nominal horse power.

PRICES OF LOCOMOTIVE MULTITUBULAR BOILERS, FIG. 1528.

| Nominal horse power | 2 | 4 | 6 | 8 | 10 | 12 | 16 | 20 | 25 | 30 | 35 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Price of boiler only 80 lbs working pres. | £35 | £52 | £67 | £80 | £93 | £109 | £130 | £154 | £189 | £220 | £247 | £254 |
| Price of do with mtngs & fittings, including ashpan and tank | £55 | £70 | £88 | £103 | £120 | £140 | £165 | £192 | £230 | £265 | £290 | £310 |
| Extra for lagging ... | £3 | £3 | £4 | £5 | £5 | £6 | £6 | £7 | £9 | £10 | £12 | £13 |
| ,, for wheels, axles & for carriage as shown | £9 | £12 | £12 | £17 | £17 | £22 | £22 | £25 | £30 | £30 | £35 | £35 |
| Appro. weight in tons | 1 | 1¾ | 2 | 2½ | 2¾ | 3 | 4 | 4¾ | 5½ | 6¼ | 7 | 7¾ |
| ,, meas. in cubic ft. | 95 | 150 | 190 | 240 | 280 | 295 | 370 | 450 | 535 | 635 | 720 | 810 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

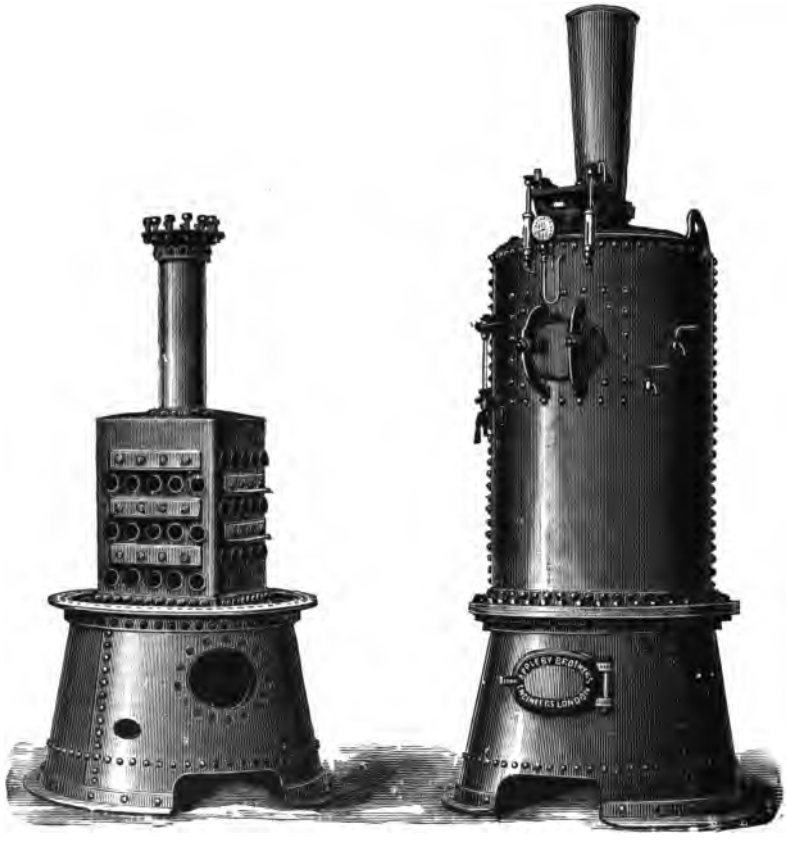


Fig. 1529.

**THE VERTICAL MULTITUBULAR BOILER** (Fig. 1529) has been specially designed to give a large supply of steam at high pressure, to occupy a very limited area, and to be perfectly accessible for periodical examination which is so necessary, and especially where the feed water is charged with foreign matter.

The engravings represent the boiler complete with fittings, and with the upper shell removed for cleaning the tubes and around the fire box; it may be well to mention that these boilers are sometimes sent away with the upper shell detached to reduce the weight of packages.

The boiler is (by preference) made of mild steel throughout, including the tubes, and the upper and lower portions are connected by heavy angle iron rings with drilled holes and turned bolts, a copper or compound asbestos packing between the flanges, making a simple and perfectly tight joint.

The enlarged fire box (shown in the engraving) should always be adopted if wood or coal of inferior quality only is available, but a fire box of the same diameter as the upper shell costs rather less and does well if good coal is used.

The important question of economy in the consumption of fuel has been independently investigated, and the tests—made in the usual manner—proved that rather more than 10 pounds of water were evaporated per one pound of coal used in these boilers.

The boilers are tested by hydraulic pressure to 200 lbs. per square inch. The fittings are as shown and include a box spanner for making the joints and a scraper for cleaning the tubes.

For prices of donkey pumps or injectors, feed water fittings, &c., see Fig. 1529, and p. 39, 40, 49, 50, &c.

PRICES FOR VERTICAL MULTITUBULAR BOILERS, FIG. 1529.

| | | | | | | |
|---|---|---|---|---|---|---|
| Nominal horse power .. .. | 6 | 8 | 10 | 15 | 20 | 25 |
| Height of shell .. .. .. | 7ft. | 7ft. | 7ft. 6in. | 8ft. | 9ft. | 10ft. |
| Diameter of shell .. .. | 2ft 9in. | 3ft. | 3ft. 3in. | 3ft. 6in. | 4ft. | 4ft. 6in. |
| Price with enlarged firebox .. | £80 | £100 | £115 | £150 | £175 | £200 |
| ,, ,, parallel ,, .. | £75 | £92 | £103 | £130 | £148 | £175 |
| ,, for fittings .. .. .. | £9 | £10 | £13 | £15 | £20 | £24 |
| ,, ,, felting and covering .. | £11 | £12 | £15 | £20 | £23 | £26 |
| Approximate weight—tons .. | 1 | 1¼ | 1½ | 2 | 3 | 4 |
| ,, measure in cubic feet | 80 | 95 | 130 | 150 | 200 | 275 |

The cost of packing for shipment and delivery f.o.b. is 3 per cent.


Fig. 1530

## THE CROSS TUBE BOILER

Type (Fig. 1530) has one or more tubes, 6in. to 8in. in diameter, placed across the fire box; the water circulates in these whilst the heated gases, &c., pass round their exterior, and are then conducted by a straight flue tube to the chimney. These boilers give good results and possess the advantage of great simplicity of construction, and consequent facility for cleaning, rendering them peculiarly suitable for employment where only bad water can be obtained; and numbers of them have been employed with extremely satisfactory results for supplying steam to cranes, travellers, small winding and pumping engines, &c.

**The plates** are of mild steel or wrought iron of suitable qualities; the longitudinal seams are double rivetted in the larger sizes, and every boiler is tested by hydraulic pressure to 140lbs. per square inch and is sent out with all the fittings shown (if so ordered) including the chimney, also fusible plug in the crown of the fire box, fire bars, bearing ring and stoking tools.

**The steam fittings** comprise double safety valves, dial steam pressure gauge with syphon pipe, two gauge cocks, water gauge and spare glass tube, and blow-off cock.

**The feed water fittings** (if ordered) include all valves and accessories ready for attachment to the water supply.

Having regard to the low price of these boilers, the simplicity of construction and the facility for keeping them clean, even when using water charged with impurities, they are often found quite as economical as those of more complicated design; this remark applies specially to boilers which are used intermittently and by unskilled drivers.

**For wood fuel** the boilers should be two sizes larger than those fired with coal.

**For 100 lbs. working pressure** the extra **cost** is about 10 per cent.

PRICES OF VERTICAL CROSS-TUBE BOILERS, Fig. 1530.

| Nominal horse power .. | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|
| Height of shell .. .. | 5ft 6in. | 6it. | 7ft. | 7ft. | 7ft. | 7ft 6in. | 8ft. | 8ft. | 9ft 6in. | 11 ft |
| Diameter of shell .. | 2ft 6in | 2ft 9in. | 2ft 9in. | 3ft. | 3ft 6in. | 3ft 6in. | 3ft 6in. | 4ft. | 4ft. | 4 ft. |
| Price of boiler .. .. | £23 | £26 | £32 | £35 | £43 | £48 | £53 | £57 | £65 | £75 |
| ,, of boiler and fittings | £28 | £32 | £38 | £41 | £50 | £55 | £60 | £65 | £74 | £85 |
| Extra for felting & covering | £5 | £6 | £7 | £8 | £9 | £10 | £11 | £11 | £12 | £12 |
| ,. donkey pump & fittings | £10 | £11 | £12 | £12 | £13 | £15 | £15 | £16 | £16 | £17 |
| ,, injector and fittings | £4 | £5 | £6 | £6 | £7 | £7 | £8 | £8 | £8 | £9 |
| Approx. weight in cwts. | 12 | 17 | 20 | 22 | 25 | 29 | 33 | 39 | 45 | 51 |
| ,, measure. in cubic ft. | 55 | 70 | 80 | 98 | 115 | 132 | 142 | 176 | 230 | 245 |

The cost of packing for shipment and delivery f.o.b. is 3 per cent.

**FIELD TUBE BOILERS** occupy little space in proportion with the power they develop and generate steam rapidly and economically. Externally, they are as shown in Fig. 1530 but, internally, the cross tubes are replaced by a number of the well known "Field" tubes which are suspended from the crown of the fire box and provide the required heating surface. The prices include the usual furnace fittings, chimney, &c., and the price of the usual steam fittings is given separately.

PRICES OF FIELD TUBE BOILERS.

| Nominal horse power .. | 2 | 3 | 4 | 6 | 8 | 10 | 12 | 16 |
|---|---|---|---|---|---|---|---|---|
| Heating surface square ft. | 38 | 50 | 65 | 95 | 125 | 155 | 160 | 225 |
| Price of boiler .. .. | £25 | £35 | £42 | £53 | £65 | £75 | £85 | £100 |
| ,, steam fittings .. .. | £7 | £7 | £8 | £9 | £10 | £10 | £1 | £12 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**COLONIAL TUBULAR BOILERS**, as illustrated by Fig. 1531, are so named because, although well adapted for firing with ordinary coal, they were originally designed for use in colonies, where, at that time, the only fuel available was wood, inferior coal or refuse fibre, and where there was an entire absence of skilled labour.

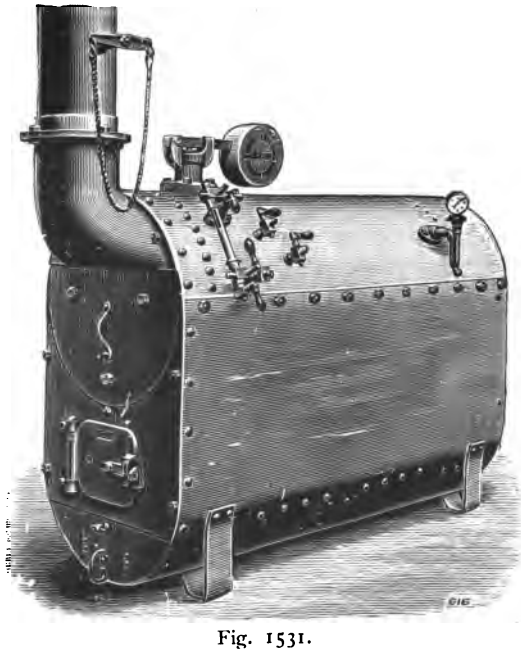


Fig. 1531.

For these reasons it was desirable that the boilers should be self contained, requiring no brick setting or foundations and should be ready for work wherever they were set down; it was also a condition, and under the circumstances a most important one, that every facility should be afforded for examination, cleaning, &c.

The grate area and heating surface, stated below, are in excess of those usually adopted for boilers of other types, and the heated gases are carried through the tubes on their passage to the chimney, after the flame has given off a large portion of its heat to the parts over the fire grate.

The subjoined prices include fire bars and bearers, elbow and chimney, man hole and mud hole; and the steam fittings comprise a safety valve with dead weight or Salter's spring balance, a dial steam pressure gauge, water gauge and trial cocks.

The boilers are built of mild steel and are tested by hydraulic pressure to 120 lbs. per square inch; the working pressure usually does not exceed 60 lbs. per square inch.

PRICES OF COLONIAL TUBULAR BOILERS, Fig. 1531.

| | | | | | | |
|---|---|---|---|---|---|---|
| Nominal horse power .. .. .. | 4 | 6 | 8 | 10 | 12 |
| Heating surface, square feet .. .. | 50 | 65 | 115 | 200 | 235 |
| Price of boiler .. .. .. .. | £48 | £55 | £65 | £95 | £110 |
| ,, injector and fittings .. .. | £6 | £7 | £8 | £10 | £12 |
| Approx. weight in tons .. .. .. | 1¼ | 1½ | 2 | 2¾ | 3½ |
| ,, measurement in cubic feet .. | 55 | 60 | 95 | 120 | 170 |

The cost of packing for shipment and delivery f.o.b. is 3 per cent.

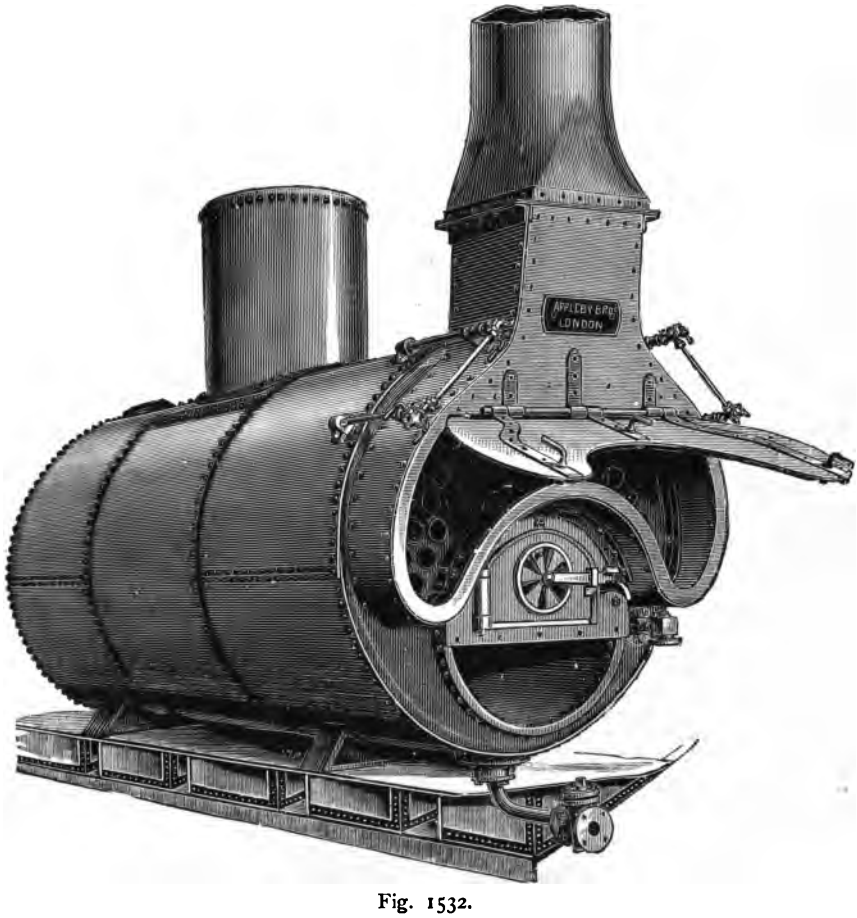



Fig. 1532.

**MARINE BOILER**, Fig. 1532.—This well known type of boiler is constructed (by preference) of best mild steel plates, carefully finished and fitted in accordance with Board of Trade rules, and tested by hydraulic pressure to 150 lbs. per square inch, equivalent to an initial working pressure of 80 lbs. to 100 lbs. This, taken in conjunction with the heating surface specified, gives a large margin of power beyond that stated in each case, and great economy in consumption of fuel.

The boilers are complete with all usual mountings, uptake and chimney and the steam fittings include a steam pressure gauge, whistle, scum and blow off cocks, &c.

Boilers will be built of suitable qualities of iron plates if so ordered, and a Board of Trade Certificate will be furnished on payment of the fees by the purchasers; these will be about £5 5s., including test by hydraulic pressure, plus Inspector's out of pocket expenses which are usually of small amount.

Prices for marine boilers of large powers will be subject to special estimates.

PRICES OF MARINE BOILERS, Fig. 1532.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nominal horse power .. .. | 6 | 8 | 10 | 12 | 15 | 20 | 25 | 30 |
| Length of boiler .. .. | 6ft. | 6ft 6in. | 6ft.6in | 7ft. | 7ft.6in. | 8ft. | 9ft.6in. | 9ft.6in. |
| Diameter ,, .. .. | 4ft. | 4ft.6in. | 5ft. | 5ft. | 5ft.6in. | 6ft 6in | 7ft.3in. | 8ft. |
| Heating surface, square feet .. | 95 | 130 | 155 | 190 | 230 | 350 | 489 | 600 |
| Price with furnace fittings .. | £90 | £108 | £127 | £140 | £155 | £210 | £285 | £375 |
| ,, extra for steam fittings .. | £8 | £9 | £10 | £11 | £13 | £15 | £16 | £18 |
| Approximate weight in cwts... | 40 | 50 | 59 | 70 | 84 | 110 | 143 | 170 |

The cost of packing for shipment and delivery f.o.b. is 3 per cent.

**DOUBLE FURNACE MARINE BOILERS** are similar in form to the single flue boiler Fig. 1532, the sections of plates and the details of construction being modified to suit the larger dimensions and the higher pressures specified in the lists of approximate prices.

It will be understood that any desired power is obtained by duplicating the boilers or arranging them in groups, also any other size will be made.

**The plates** are of the highest quality Siemens-Martin steel and are tested before they are used. The edges of the plates are planed, all holes are drilled and both flanging and rivetting are done by hydraulic machine.

**The longitudinal seams** are butt jointed with double cover strips, double rivetted, and the staying is in accordance with the best modern practise.

**The testing** is by hydraulic pressure to 1¾ times the maximum working pressure.

**The accessories** include the uptake for securing to the funnel, doors to smoke box, &c.; furnace doors, frames and fire grates, steam and feed water fittings.

**The steam fittings** comprise asbestos packed water gauge, trial cocks, spring safety valve, dial pressure gauge, Bourdon's system, gun metal feed valve, main steam valve, gun metal blow off cock, spare gauge glasses, &c.

PRICES OF DOUBLE FURNACE MARINE BOILERS FOR 100 LBS. PRESSURE.

| | | | | | | |
|---|---|---|---|---|---|---|
| Indicated horse power .. .. | 100 | 125 | 150 | 175 | 210 | 245 |
| Length of boiler .. feet | 7 | 8½ | 8 | 9 | 8½ | 10 |
| Diameter ,, .. ,, | 7 | 7⅓ | 8 | 8½ | 9 | 9 |
| ,, of flues .. inches | 27 | 28½ | 30 | 33 | 36 | 36 |
| Number of tubes 3 inch diameter | 66 | 72 | 85 | 100 | 115 | 115 |
| Heating surface .. square feet | 400 | 500 | 550 | 625 | 725 | 875 |
| Price of boiler and fittings .. | £340 | £370 | £395 | £435 | £480 | £530 |
| Approximate weight .. tons | 9¼ | 10½ | 11 | 12½ | 14¼ | 16¼ |
| ,, measure. cub. ft. | 800 | 960 | 1040 | 1080 | 1420 | 1600 |

The cost of packing for shipment and delivery f.o.b. varies but for purposes of estimate may be taken at about 5 per cent.

**Double furnace marine boilers for 150 lbs. pressure.**—The approximate cost of boilers similar in dimensions, construction and quality of materials, &c., to those last referred to, and complete with fittings and accessories as specified, are as follows:—

PRICES OF DOUBLE FURNACE MARINE BOILERS FOR 150 LBS. PRESSURE.

| | | | | | | |
|---|---|---|---|---|---|---|
| Heating surface, square feet .. | 400 | 500 | 550 | 625 | 725 | 875 |
| Price of boiler and fittings .. | £410 | £460 | £470 | £535 | £590 | £650 |

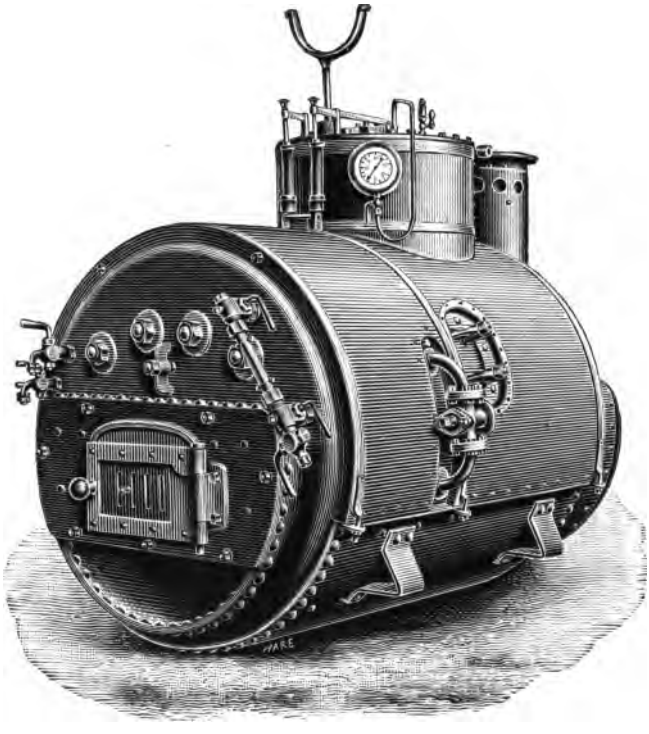


Fig. 1533.

**BOILERS FOR STEAM LAUNCHES.**—The materials used and the fittings provided, as shown in Fig. 1533, are practically the same as those referred to in the description of marine boilers, Fig. 1532, but this type is cylindrical with a view of insuring great strength and large heating surface and steam space in the smallest possible area. A test pressure of 160 lbs. per square inch is taken as a basis, this being equivalent to the usual working pressure of 80 lbs. to 100 lbs., but, at a comparatively small increase in cost, boilers will be constructed to carry such higher pressures as may be desired.

The proportions and equipments fulfil the Board of Trade requirements and a Certificate from that authority will be supplied on payment of the fees charged for inspection. All details requiring attention during construction, such as those relating to steel or brass tubes, lagging and felting, &c., should be clearly stated when the order is given.

PRICES OF BOILERS FOR STEAM LAUNCHES, Fig. 1533.

| | | | | | |
|---|---|---|---|---|---|
| Length of boiler, in feet .. .. .. | 4ft. 6in. | 5ft. | 5ft. 3in. | 5ft. 6in. | 6ft. |
| Diameter ,, ,, .. .. .. | 2ft. 10in. | 3ft. | 3ft. 3in. | 3ft. 6in. | 3ft. 6in. |
| Heating surface, square feet .. .. | 70 | 80 | 90 | 100 | 120 |
| Price with steel tubes .. .. .. | £70 | £80 | £90 | £100 | £120 |
| ,, ,, brass ,, .. .. .. | £80 | £93 | £104 | £115 | £138 |
| ,, of steam fittings .. .. .. | £12 | £13 | £14 | £15 | £16 |
| ,, of lagging and covering, sheet iron | £8 | £8 | £9 | £10 | £10 |
| Approximate weight in cwts. .. .. | 16 | 23 | 25 | 28 | 30 |
| ,, measurement in cubic feet.. | 45 | 55 | 70 | 85 | 115 |

The cost of packing for shipment and delivery f.o.b. is 3 per cent.

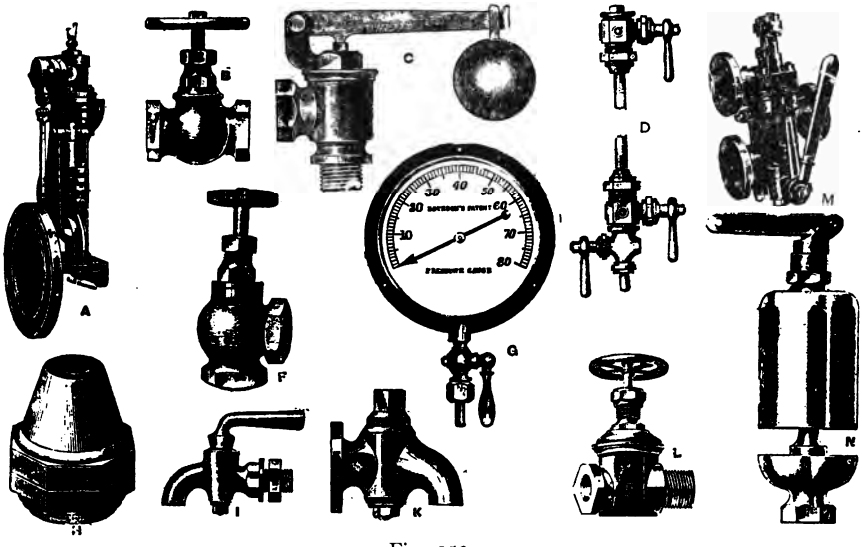



Fig. 1534.

**FITTINGS FOR STEAM BOILERS** (Fig. 1534) are referred to in most of the lists of prices of boilers, but those following will show at a glance the approximate cost of these separately, of the proportions required for boilers of all powers up to 50 N.H.P., and a working pressure up to about 80 lbs. per square inch.

PRICES OF FITTINGS FOR STEAM BOILERS, Fig. 1534.

| Type | Nominal horse power of boiler .. | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| A | Donkey Pump .. .. .. | £10 | £10 | £12 | £12 | £14 |
| M | Injector, with suction, iron body.. | £4 | £4 | £4 | £4 | £4 |
| M | ,, ,, brass body.. | £5 15 | £5 15 | £5 15 | £5 15 | £5 15 |
| G | Pressure gauge, Bourdon's .. | 16/6 | 16/6 | 19/- | 19/- | 19/- |
| C | Safety valve .. .. .. | 18/6 | 27/6 | 35/- | 41/- | 49/- |
| B | Steam valve, gun metal .. .. | 5/9 | 10/6 | 10/6 | 10/6 | 13/- |
| D | Water gauge, screwed .. .. | 19/- | 19/- | 20/- | 20/- | 20/- |
| D | ,, flanged .. .. | 21/6 | 21/6 | 22/6 | 22/6 | 22/6 |
| I | Test cocks .. .. .. .. | 3/3 | 3/3 | 4/3 | 4/3 | 4/3 |
| F | Angle check and feed valve, female | 4/6 | 4/6 | 4/6 | 6/6 | 6/6 |
| K | Gun metal cock .. .. .. | 4/3 | 4/3 | 4/3 | 5/6 | 5/6 |
| L | Blow-off cock .. .. .. | 6/6 | 7/9 | 11/- | 15/6 | 15/6 |
| H | Fusible plugs .. .. .. | 4/- | 4/- | 4/- | 4/3 | 4/3 |
| N | Buzzer .. .. .. .. | 12/6 | 12/6 | 12/6 | 15/- | 15/- |

| Type | Nominal horse power of boiler .. | 7 | 8 | 9 | 10 | 12 |
|---|---|---|---|---|---|---|
| A | Donkey pump .. .. .. | £14 | £14 | £16 | £16 | £16 |
| M | Injector, with suction, iron body.. | £4 | £5 | £5 | £5 | £5 |
| M | ,, ,, brass body.. | £5 15 | £6 15 | £6 15 | £6 15 | £6 15 |
| G | Pressure gauge, Bourdon's .. | 21/- | 21/- | 21/- | 21/- | 21/- |
| C | Safety valve .. .. .. | 49/- | 59/- | 59/- | 69/- | 69/- |
| B | Steam valve, gun metal .. .. | 13/- | 17/6 | 17/6 | 20/- | 20/- |
| D | Water gauge, screwed .. .. | 25/- | 25/- | 30/9 | 30/9 | 30/9 |
| D | ,, flanged .. .. | 27/6 | 27/6 | 33/6 | 33/6 | 33/6 |
| I | Test cocks .. .. .. .. | 6/3 | 6/3 | 6/3 | 6/3 | 6/3 |
| F | Angle check and feed valve, female | 6/6 | 6/6 | 8/6 | 8/6 | 8/6 |
| K | Gun metal cock .. .. .. | 5/6 | 5/6 | 7/3 | 7/3 | 7/3 |
| L | Blow-off cock .. .. .. | 18/6 | 18/6 | 18/6 | 26/- | 26/- |
| H | Fusible plugs .. .. .. | 4/3 | 7/9 | 7/9 | 7/9 | 7/9 |
| N | Buzzers .. .. .. .. | 15/- | 17/- | 17/- | 17/- | 21/- |

PRICES OF FITTINGS FOR STEAM BOILERS, Fig. 1534—Continued.

| Type | Nominal horse power of boiler .. | 14 | 16 | 18 | 20 | 25 |
|---|---|---|---|---|---|---|
| A | Donkey pump .. .. .. | £16 | £16 | £16 | £20 | £20 |
| M | Injector with suction, iron body .. | £6 | £6 | £6 | £6 | £6 |
| M | ,, ,, brass body.. | £8 10 | £8 10 | £8 10 | £8 10 | £8 10 |
| G | Pressure gauge, Bourdon's .. | 24/- | 24/- | 24/- | 24/- | 24/- |
| C | Safety valve .. .. .. | £3 17 6 | £3 17 6 | £4 17 6 | £4 17 6 | £6 |
| B | Steam valve, iron .. .. .. | £1 11 6 | £1 11 6 | £2 0 6 | £2 0 6 | £2 10 6 |
| D | Water gauge. screwed .. .. | 30/9 | 30/9 | 30/9 | 30/9 | 30/9 |
| D | ,, flanged .. .. | 33/6 | 33/6 | 33/6 | 33/6 | 33/6 |
| I | Test cocks .. .. .. .. | 6/3 | 6/3 | 6/3 | 6/3 | 6/3 |
| F | Angle check and feed valve, female | 8/6 | 8/6 | 11/6 | 11/6 | 13/9 |
| K | Gun metal cock .. .. .. | 7/3 | 7/3 | 10/6 | 10/6 | 13/9 |
| L | Blow-off cock .. .. .. | 31/6 | 31/6 | 52/- | 52/- | 70/- |
| H | Fusible plugs .. .. .. | 7/9 | 13/6 | 13/6 | 13/6 | 13/6 |
| N | Buzzers .. .. .. .. | 21/- | 36/- | 36/- | 36/- | 50/- |

| Type | Nominal horse power of boiler .. | 30 | 35 | 40 | 45 | 50 |
|---|---|---|---|---|---|---|
| A | Donkey pump .. .. .. | £20 | £23 | £23 | £32 | £32 |
| M | Injector with suction, iron body .. | £7 | £7 | £8 | £8 | £9 |
| M | ,, ,, brass body .. | £9 10 | £9 10 | £11 10 | £11 10 | £12 10 |
| G | Pressure gauge, Bourdon's .. | 24/- | 24/- | 27/- | 27/- | 27/- |
| C | Safety valve .. .. .. | £6 | £6 15 | £6 15 | £7 15 | £7 15 |
| B | Steam valve, iron .. .. .. | £3 | £3 | £3 13 | £4 16 6 | £4 16 6 |
| D | Water gauge, screwed .. .. | 30/9 | 30/9 | 42/6 | 42/6 | 42/6 |
| D | ,, flanged .. .. | 33/6 | 33/6 | — | — | — |
| I | Test cocks .. .. .. .. | 6/3 | 6/3 | 12/6 | 12/6 | 12/6 |
| F | Angle check and feed valve, female | 13/9 | 19/- | 24/6 | 42/- | 55/- |
| K | Gun metal cock .. .. .. | 13/9 | 19/- | 24/- | 42/- | 55/- |
| L | Blow-off cock .. .. .. | 70/- | 70/- | 70/- | 85/- | 85/- |
| H | Fusible plugs .. .. .. | 13/6 | 13/6 | 19/6 | 19/6 | 19/6 |
| N | Buzzers .. .. .. .. | 50/- | 50/- | 64/6 | 64/6 | 80/- |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.
For prices of steam tubes and connections see p

**FORCED COMBUSTION.**—Perhaps no question connected with steam raising has had more careful consideration, in recent years, than that relating to forced draught, which increases the evaporative power of good coal and renders available for steam raising, various materials—such as coke or coal dust, ash pit refuse, spent bark, as well as other matter—which have hitherto been regarded as refuse—and they are specially adapted for firing with anthracite coal.

Various mechanical difficulties have been experienced in the production of appliances for this purpose which, at a moderate cost can be attached to new or to any existing boiler, and in which the intensity of the blast is easily regulated to obtain perfect combustion of any kind of fuel which may be procurable at low cost, together with the absence of machinery and its contingent cost of maintenance.

Amongst the numerous devices for effecting the objects above referred to, those now mentioned will be found to give good results. They are quite moderate in cost but, as the proportions, kind of attachments, &c., vary with every kind and size of boiler, information on the following details is requisite for the preparation of designs and estimates of cost :—

*(a)* **The type and dimensions of boiler.** *(b)* **The dimensions of grates.** *(c)* **The kind of fuel** to be used and the quantity to be burned per hour.

If the fuel is of poor or of unknown value a sample of one or two tons will be tested, or a laboratory test made without charge, provided that furnaces are ordered.

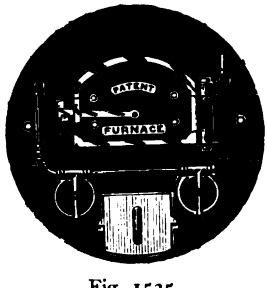


Fig. 1535.

**THE MELDRUM SYSTEM** of forced draught, illustrated by Fig. 1535, a applied to a Cornish boiler of the type Fig. 1522 may be briefly described as follows :—

Two steam jet blowers are fixed to the front plate of the boiler, as shown in Fig. 1535, one on each side of an air-tight ash pit door and immediately below the fire bars; these are supplied with steam from a single pipe with a valve, whereby the blast is regulated to any pressure up to that equal to a 6 inch water column, the working pressure of blast is, however, usually 1 to 1½ inch water column.

The fire bars, which are an important feature in the system, are provided with an interlocking arrangement to prevent lifting when being cleaned, and they are spaced less than one-eighth of an inch apart so that no fuel can be wasted by falling through into the ash pit.

The advantages claimed for this system are the perfect combustion of all fuel and the facility of using matter which cannot be consumed in the ordinary furnace. Clinker does not adhere to the fire bars, which will last for years, and the loss of fuel is so small, that the ash pit door need not be removed for clearing, more than about once a day. Also that no tall chimney is required and that the apparatus throughout is perfectly simple, easily regulated and not liable to derangement.

The apparatus can be applied to any type of boiler and the time occupied in fixing rarely exceeds 48 hours. The saving in cost of fuel has in all cases been large and the evaporative power of the boiler greatly increased.

**THE GOSLING SYSTEM** (not illustrated) effects the objects referred to in the foregoing remarks on forced combustion, but the arrangements whereby this result is obtained, differ in details from those illustrated and described.

In the Gosling forced draught furnace the blast—provided by an injector fixed in front of boiler—is carried in a semi-cylindrical box fixed just below the fire bars and extending nearly to the bridge; the upper part of the box is perforated at intervals and, by this means, the draught or blast is distributed at a uniform pressure under the whole area of the grates. The result of this is that the fire is bright all over instead of being so in places, comparatively black in others and—where the fire is thin—blowing through and leaving bare patches on the fire bars.

Experience has shown that, with this system of forced draught, a better result is obtained with an open than with a closed ashpit; that the blast does not attack the weak places in the fire and that it is intensely bright all over the bars; there is a total absence of explosive back draught and a high evaporative duty is steadily maintained.

As already indicated the cost of the apparatus cannot be accurately determined without the data above refered to, but it may be assumed that the appliances necessary for flues of about 2 feet 8 inches diameter will cost about £40 for a Cornish boiler or £70 for the two flues of a Lancashire boiler.

**MECHANICAL STOKERS,** whatever system is adopted, gradually and automatically project the fuel into the hottest part of the furnace, with closed doors, thus avoiding the rush of cold air which enters the furnace every time the doors are opened.

The advantages derived from the complete combustion of fuel, and the absence of black smoke from the chimney, are now so generally recognised, that few ranges of large boilers are without these labour and coal saving appliances.

Probably not one of the types in use, will be found absolutely satisfactory with all kinds of coal, and under all conditions, but carefully kept statistics show that, if the system of stoker is properly adapted to the fuel, &c., the saving in total expenditure should average at least 10 per cent. But the McDougall mechanical stoker illustrated by Fig. 1536 is adapted for use with so many classes of boilers and of fuel, that the following data may be useful as indicating the mode of working and the approximate cost of the appliances.

If advice is desired in regard to the system to be adopted, full information should be given as to the fuels to be used. Analyses of them give the best data, but in the absence of this, it should be stated whether the coal is hard or soft, quick or slow in combustion, and whether there is a tendency to "clinker" or to leave a large quantity of ashes.

**The McDougall Mechanical Stoker** is shown in Fig. 1536 as fixed to a Lancashire boiler, but the apparatus is equally applicable to other types of internally or externally fired boilers and amongst the advantages claimed for it are the saving of labour and fuel and the prevention of smoke by reason of the complete combustion of fuel; also the absence of parts liable to derangement, and the facility of resorting to hand firing when desired.

The mode of working is as follows:—

Power is transmitted by rope or belt to cone speed pulleys, shown on the left; the fuel is forced over the coking plate by a ram moving on the bottom of the hopper, the quantity and size of fuel being regulated by a shutter easily manipulated from the front by the hand wheel and screw as shewn. The fire bars are actuated by a series of cams threaded on to a hexagon shaft—these cams are alternately arranged, each bar resting on and being driven by its own eccentric or cam. At the bridge end the undersides of the bars are bevelled, and rest on a similarly bevelled portion of the bridge plate. When the cam shaft revolves, it is evident how a bar, in being lifted by its cam at the front end, is at the same time thrust forward, and running up the incline is also lifted at that point. Whilst this occurs the contiguous bars are depressed by being drawn backwards. The fuel on the bars is carried forward and burnt at a rate dependent on the speed at which the cam shaft is driven, and thus the rate of combustion is easily under command. The clinker also, as it is formed, travels from the front to the bridge, on which it is deposited, and is finally pushed over into the flue, and withdrawn by the door provided for that purpose. The bars are spaced sufficiently apart for the supply of air for combustion. The feeding arrangement is very simple and effective, and there are no working parts to get out of order.

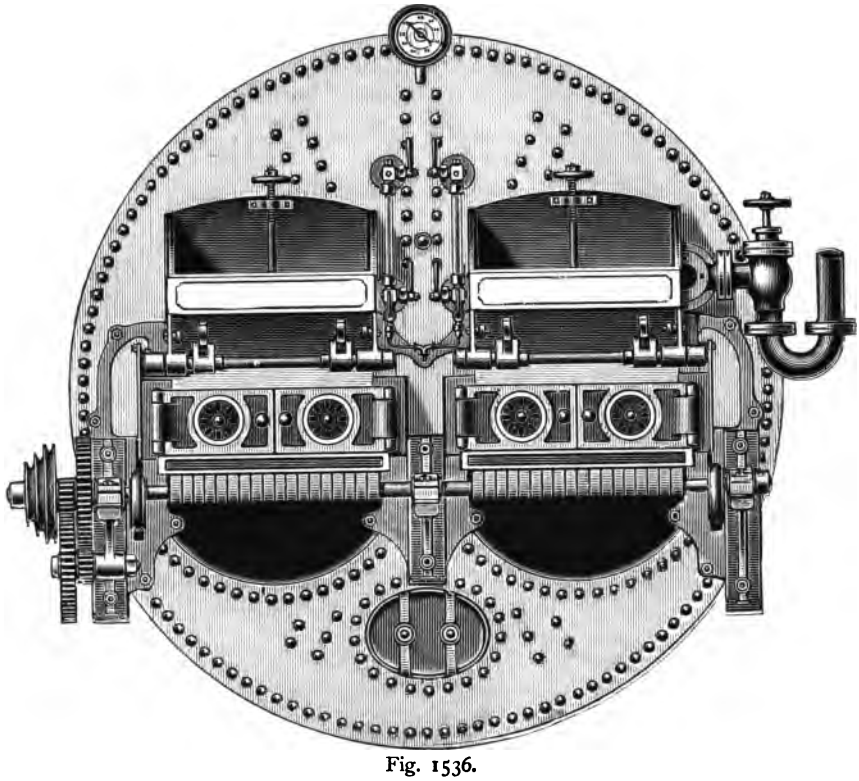


Fig. 1536.

The following may be regarded as the approximate cost of these appliances ready to fix to the boiler, exclusive of driving power and—with little modification—these prices will apply to stokers for boilers differing in type but of about equal power. It will be understood that the prices are for a Lancashire boiler and the single set for a Cornish boiler.

PRICES OF MECHANICAL STOKERS, Fig. 1536.

| | | | |
|---|---|---|---|
| Diameter of Lancashire boiler .. .. .. .. | 7ft. | 7ft. 6in. | 8ft. |
| Ditto each furnace .. .. .. .. | 2ft. 9in. | 3ft. | 3ft. 3in. |
| Price of apparatus .. .. .. .. .. | £70 | £75 | £80 |

| | | | |
|---|---|---|---|
| Diameter of Cornish boiler .. .. .. .. | 5ft. | 5ft. 6in. | 6ft. |
| Ditto furnace .. .. .. .. .. | 2ft. 6in. | 2ft. 9in. | 3ft. |
| Price of apparatus .. .. .. .. .. | £42 | £48 | £54 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**ROCKING OR MOVING FIRE BARS** are used with a view of obtaining more complete combustion of fuel than can be obtained with the ordinary bars and thus reduce or prevent the escape of black smoke from the chimney.

In the Writer's experience, moving bars have been condemned when the only mistake has been that the wrong system has been adopted, so that care must be taken to select that most suitable for the fuel to be used, and the information requisite to decide this question is, practically, the same as for Mechanical Stokers.

**BOILER CHIMNEYS.**—The dimensions of chimneys are affected by many circumstances, amongst which may be mention, the absence of suitable building materials for masonry chimneys or the skill to use them, the consumption of fuel per square foot of grate area, the length and sections of flues, local considerations as to height, atmospheric conditions, and those relating to foundations, &c., all of which must be taken into account, even when using the formulæ which will be found in Section VII. The following approximate prices of a few sizes of wrought iron chimneys may however frequently save loss of time in correspondence when, for various reasons, these are required.

**WROUGHT IRON CHIMNEYS** are used with advantage in many localities and especially those which present difficulties in regard to the foundations requisite to carry a heavy structure. They last a very long time if they are lined with fire bricks to half or two-thirds the height and are periodically protected by paint or coal tar.

The chimneys are built of wrought iron plates and, for shipment, they are made in three or more lengths with strong angle iron rings which are sent loose to admit of the several lengths nesting one inside the other, to avoid damage in transit and to reduce the cost of freight, the rings being rivetted up at destination.

The thickness of plate in the bottom section is always greater than those in the upper sections and the latter are reduced in diameter sufficiently to admit of the nesting just referred to. The base is made of cast or wrought iron—usually the latter—with a strong angle iron ring at the bottom for securing it to the base plate; this is attached to the foundations by Lewis bolts which are supplied, together with rivets for completing the chimney when erected; the stays are galvanized steel wire rope with tightening screws, shackles, &c.

The following prices include all the metallic work but not fire bricks for lining; these will however be supplied, if desired, at current rates. If for any reason it is desired that the sections of plates should be thicker than those ordinarily used, the extra cost will probably be 5 to 10 per cent.

PRICES OF PARALLEL WROUGHT IRON CHIMNEYS.

| Diameter of chimney | feet | 2 | 2½ | 2½ | 3 | 3 | 3 | 3½ | 3½ | 4 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Height | ,, | ,, | 30 | 40 | 50 | 40 | 50 | 60 | 50 | 60 | 50 | 60 |
| Price | ,, | ,, | £16 | £30 | £36 | £35 | £45 | £50 | £55 | £68 | £70 | £85 |

**Taper chimneys,** frequently preferred for various reasons—appearance being one—are sent in separate plates to be rivetted together at destination or in three or more lengths, the upper lengths nesting in the lower lengths and so reducing cost in freight and in erection.

The subjoined prices include a neat cast iron moulding for the top of the chimney and the usual accessories as indicated in the foregoing description.

PRICES OF TAPER WROUGHT IRON CHIMNEYS.

| Diameter at bottom | feet | 4½ | 4½ | 4½ | 5 | 5 | 5 | 5½ | 5½ | 6 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ditto at top | ,, | 3¼ | 3¼ | 3¼ | 3½ | 3½ | 3½ | 3¾ | 3¾ | 4 | 4 |
| Height of chimney | ,, | 50 | 60 | 75 | 60 | 75 | 100 | 75 | 100 | 100 | 120 |
| Price ,, .. | .. | £85 | £100 | £120 | £110 | £130 | £155 | £160 | £190 | £200 | £230 |

**STEAM SUPERHEATERS.**—The advantages derived from the use of superheated dry steam have long been recognised, but the difficulty in controlling the temperature and the inconvenience experienced in maintaining packings and efficient lubrication, have hitherto prevented the system of superheating coming into general use.

The difficulties above referred to have, however, now been entirely removed by a simple and automatic arrangement, applicable to new or to any existing boilers whereby perfectly dry steam is obtained, priming is rendered impossible, and the temperature is controlled and maintained within any limit desired.

The effect of this is that, without in any way interfering with packings and lubrication, a marked increase is obtained from the power developed from a given volume of steam generated in the boilers and a considerable decrease in the consumption of fuel. The importance of these economies is obvious, and especially so where fuel is expensive; in any case, the saving in the cost of fuel alone will soon more than cover the entire cost of the apparatus, whilst the gain in power may often avoid the necessity of putting down new boilers and engines to replace those which have been under power.

The arrangement of the apparatus is varied to suit the proportions and class of boilers with which it is to be used, so that the cost of an installation cannot be ascertained without information on these points.

**THE SCHWOERER SUPERHEATER,** is composed mainly of cast iron tubes with large external and internal corrugations, the object of the former being to absorb the heat from the escaping gases, and of the latter to give the largest possible superheating surface. The jointing of the superheater pipes, which has hitherto presented difficulties never before satisfactorily overcome, is effected by a ring of mild steel with a special composition of cement between the annular spaces and squeezed together by the joint bolts. This joint, which has been patented, perfectly resists the heat but expands freely; the result is that a joint so made has never yet failed.

The superheater pipes are fixed in the flue of the boiler in a serpentine manner and the steam taken from the boiler travels through them on its way to the steam pipe to the engine room.

From trials made by Professor Cawthorne Unwin, F.R.S. in connection with an engine of 500 horse power and from other independent trials it appears that the saving in fuel effected by the Schwoerer Superheater ranges from 13 to 20 per cent., whilst engines which have worked for two years in conjunction with this type of superheater are quite uninjured by the temperature of the steam. The question of economy has been further confirmed by continuous working for a month with an externally fired boiler. The fuel was anthracite with about 13 per cent. of coke breeze and the boiler was provided with blowers of the type Fig. 1535. The mean temperature of steam was 121° fahr. the consumption of fuel was 2.58 lbs. per **pump** horse power per hour, and the saving in fuel about 15 per cent.

**CONDENSERS.**—Jet and surface condensers are referred to in connection with some of the types of engines illustrated and described and the cost is given for condensers suitable for the conditions fulfilled by those engines; but as the capacity of the condenser, air pumps, and accessories must be in proportion with the volume and pressure of steam used, details of these and of other matters relating to the installation must be furnished before accurate estimates can be made. Reference is now made to some other forms of condensers which are largely employed under normal conditions and may be relied upon to give good results if they have the proper proportions and are properly fixed.

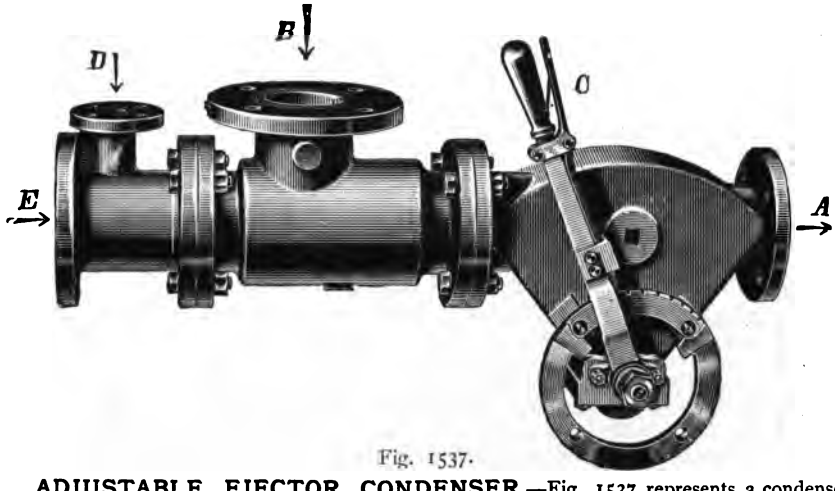



Fig. 1537.

**ADJUSTABLE EJECTOR CONDENSER.**—Fig. 1537 represents a condenser which may be connected to a new or any existing engine to increase its power or to save fuel, and may be fixed on a level with the supply of condensing water or, if necessary, a few feet above it; the capacity is regulated by a sliding nozzle which is adjusted by the lever **C** to suit wide variations in the load on the engine.

The condensing water enters at **E** and passes through the adjustable nozzle in a solid jet and is discharged at **A.** The exhaust steam enters at **B** and the velocity of the jet of condensing water suffices to discharge it, and a certain volume of air, at **A** against the resistance due to atmospheric pressure. The connection **D** conveys a jet of live steam which is used for starting the condenser when it is fixed at a higher level than the water supply, an arrangement which should, as far as possible, be avoided.

It is claimed that a vacuum of 10 to 12 lbs. per square inch will be maintained with a consumption of condensing water about 20 per cent. less than that required for condensers of the ordinary type. It will be seen from the foregoing description that no air pump is required and that the condenser may be used under widely differing conditions.

It is essential, for permanently satisfactory working that all joints should be tight, and that the size of condenser used should be in proportion with :—

1. The volume (by preference the weight) of steam used in a given time.
2. The variations in load and consequent variation in weight of steam to be condensed.
3. The relative positions of engine and condenser with the existing or proposed supply of condensing water.

PRICES OF ADJUSTABLE EJECTOR CONDENSERS, Fig. 1537.

| | | | | | | |
|---|---|---|---|---|---|---|
| Water required per hour gallons | 880 | 1320 | 1760 | 2640 | 3520 | 4840 |
| Price of condenser .. .. | £20 | £25 | £30 | £35 | £40 | £45 |
| Ditto stop valve for exhaust .. | £3 10 | £4 | £4 | £6 | £7 10 | £9 |
| Ditto strainer for supply pipe | 15/- | £1 | £1 5 | £1 10 | £1 15 | £1 15 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**EJECTOR CONDENSERS WITH OVERHEAD SUPPLY.**—This type is adapted for use with engines which are subject to frequent and great variation in load.

The head of condensing water should be not less than 15 feet and the apparatus must have the proportions for dealing with exhaust produced under the greatest load. The quantity of water required is about 100 gallons per indicated horse power per hour, allowing 40 lbs. of steam per indicated horse power per hour.

PRICES OF EJECTOR CONDENSERS WITH OVERHEAD SUPPLY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Water required per hour gallons | 792 | 1320 | 2640 | 3960 | 5280 | 6600 |
| Price of condenser .. .. | £8 | £11 | £13 | £16 | £20 | £24 |
| Ditto non return valve .. | £2 | £2 10 | £3 | £4 | £5 | £5 |
| Ditto strainer and foot valve.. | £1 5 | £1 5 | £1 10 | £2 10 | £2 10 | £3 |
| Ditto stop valve for exhaust .. | £3 10 | £5 | £7 10 | £11 | £18 | £29 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**EJECTOR CONDENSER FOR HIGH SPEED ENGINES.**—By a modification of the construction last referred to these condensers are specially adapted to work with engines which are subject to slight variations in revolutions or in the power developed and, being entirely self-acting, they can be applied to high speed engines which cannot be conveniently worked in conjunction with an air pump condenser. The prices are the same as for the overhead supply condensers.

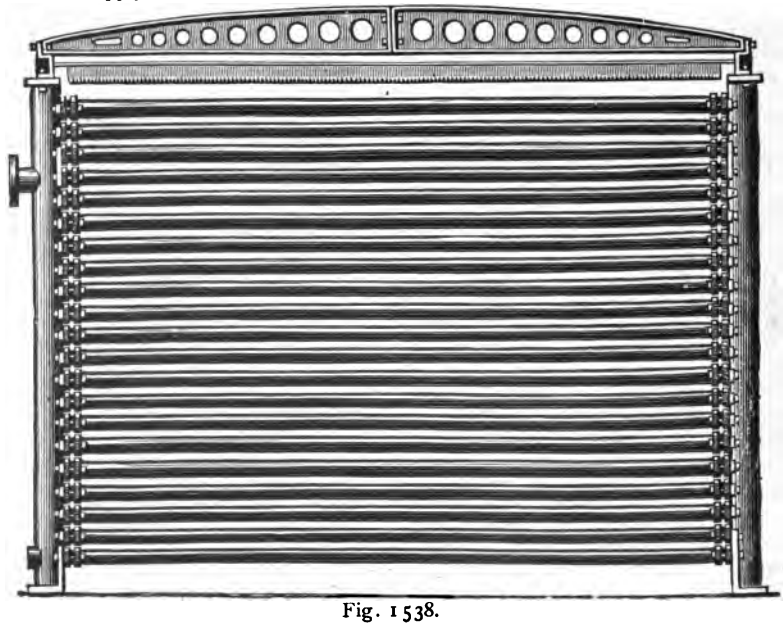


Fig. 1538.

**EVAPORATIVE SURFACE CONDENSERS.**—The system illustrated by Fig. 1538 may be applied to any existing engine and used with advantage where the supply of water for condensation is limited or costly. Careful test in the Writer's works has shown a saving in fuel of about 20 per cent. and a gradual subsidence of the thick scale which had caused great inconvenience. The apparatus may be fixed at a considerable distance from the engine and the more exposed the situation the better is the result obtained; the absence of any element liable to derangement is in favour of the use of this type of condenser, in isolated places, in connection with high or low speed engines, vacuum pans, &c.

A number of condensers of this construction are grouped to deal with any volume of exhaust steam and to suit almost any space.

The condenser consists of a number of copper tubes with cast-iron boxes at each end, and a copper trough with serrated edges at the top, as shown in the engraving. The steam to be condensed is admitted into the cast iron boxes, and spreading through the copper pipes the condensation is effected by a shower of water flowing over the serrated edges of the copper trough and trickling down over the exterior of the pipes. Thus the condensing water absorbs not only its proportion of sensible heat, but also some latent heat, and as the water lost by evaporation outside the tubes is only equal to that produced by the condensation of the steam within them, the consumption of water is but little more than is required for an ordinary high pressure engine of equal power, because the condensed water is returned to the boiler in a heated state, and so is used again.

The data required for estimating the size and cost of the condenser required is furnished by an indicator diagram, or if that cannot be obtained it will be necessary to give—

The temperature of steam as it leaves the cylinder, or the initial pressure and point of cut off.

The diameter, length of stroke, and number of revolutions made by the engines.

The position of the condenser relatively with the engines.

**FEED WATER HEATING AND PURIFICATION.**—The often quoted fact, that scale one sixteenth of an inch thick on the heating surface of boilers involves an increase of 15 per cent. in the consumption of fuel, and that the thicker the scale the greater is the waste of fuel, forms one of the strongest arguments in favour of the use of these appliances which eliminate the scale forming matter in the process of heating the water and deliver it to the boiler at a high temperature.

Fig. 1539.

It is well known that the degree of heat necessary to effect this deposit varies with the nature of the ingredients in the water, some (carbonate of lime, magnesia and organic or other dirty matter) being deposited at a temperature of about 195°, whilst a much higher degree of heat is required to deposit other ingredients, more especially sulphates of lime and unless the kind and proportion of scale forming matter are accurately known, careful analyses should be made. This will be done, free of charge (before the apparatus is constructed) for the purpose of determining the type and proportions requisite to ensure satisfactory results.

However varied in design and arrangement appliances for this purpose may be, the heat is imparted to the feed water by :—

1. The steam exhausted from a high pressure engine.
2. The waste heat in the flue between boiler and chimney, or
3. By live steam taken direct from the boiler.

To these might be added, the injector which (although not generally recognised as a water heater) imparts to the feed water the whole of the heat in the steam used for injection.

**FEED WATER HEATERS,** Fig. 1539 (Brown's patent) consists of a wrought iron casing provided with the intakes and outlets indicated in the engraving, the bottom cover being easily removable for examination and cleaning.

The interior is fitted with a series of curved brass tubes which are free to expand and contract independently of each other and thus cause the scale forming matter deposited on the pipes whilst the feed water is being heated, to fall to the

bottom, whence it is discharged at intervals through the mud cock at the bottom of casing.

Large numbers of these heaters are in constant use, with universal satisfaction as regards economy and maintenance. They effect a saving of from 10 to 20 per cent. in the consumption of fuel and deliver the water to the boiler at a uniform temperature, freed from grease and much foreign matter. The prices of some of the sizes in general use and the approximate capacity in gallons of water heated per hour, &c., will be found in the following tables.

PRICES OF FEED WATER HEATERS, Fig. 1539.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capacity, gallons per hour .. | 280 | 390 | 500 | 600 | 850 | 1050 | 1600 | 2600 |
| Heating surface, square feet .. | 40 | 56 | 70 | 85 | 120 | 155 | 230 | 370 |
| Price of heater .. .. .. | £35 | £45 | £50 | £68 | £80 | £95 | £145 | £225 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**SPIRAL TUBE FEED WATER HEATERS** are made for use with live or exhaust steam and are exceedingly compact and efficient. The casing is fitted internally with coiled copper tubes through which the steam passes and heats the feed water by radiation. The tubes are free to expand and contract and this action causes the scale and grease to fall to the bottom of the casing and so purify the water before it enters the boiler, the result being a large economy in the consumption of fuel and a saving of time and expense in cleaning the boiler.

Fig. 1540.

**Live steam feed water heaters,** Fig. 1540.—Although the use of steam taken direct from the boiler for heating feed water would, a few years ago, have been regarded as retrograde, the results obtained demonstrate, beyond doubt, that the system effects a distinct saving in consumption of fuel and in boiler maintenance. The former is probably due to the elimination of matter which would form scale, and the latter to the great diminution in contraction and expansion due to the equable and (comparatively) high temperature of the feed water when it enters the boiler. The connection for the steam inlet pipe is at **I** in the engraving Fig. 1540 and that for the feed pipe from pumps is with one or other of the flanges at the bottom of the casing. The pipe conveying the heated water to boiler is connected to the flange at the top which may be on either side as shown in dotted lines. The cock at the base is the outlet for condensed steam to the hot well and the pipe at the top of the apparatus is for connection with the hot well air space; doors are provided for thoroughly cleaning internally.

The cost of heaters of intermediate or larger capacities is in proportion with those given in the following list.

PRICES OF LIVE STEAM FEED WATER HEATERS, Fig. 1540.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| For indicated horse power.. | 100 | 200 | 300 | 500 | 800 | 1000 | 1500 | 3000 |
| Price of heater .. .. | £28 | £33 | £40 | £58 | £75 | £95 | £115 | £200 |

**Exhaust steam feed water heaters.**—The feed water enters the heater casing at the bottom and is heated by contact with a group of S shaped brass tubes through which the steam passes in a downward direction. The impurities in the feed water are deposited on the tubes and, as these expand and contract, the scale combined with grease, falls to the bottom and is removed from time to time.

The apparatus is complete with all requisite fittings including ample provision for cleansing.

PRICES OF EXHAUST STEAM FEED WATER HEATERS.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| For indicated horse power .. | 25 | 50 | 75 | 100 | 200 | 250 | 300 | 400 |
| Diam. of exhaust connection, ins. | 3 | 4 | 5 | 6 | 8 | 9 | 10 | 12 |
| Price of heater .. .. .. | £33 | £48 | £60 | £75 | £135 | £170 | £200 | £260 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**ECONOMISERS.**—This well known form of heater (Green's system) consists of a series of groups of vertical tubes of about 4½ inches external diameter, which are fixed in the main flue and heated by the products of combustion on their passage from the boiler to the chimney, the number of tubes being in proportion with the quantity of feed water to be heated.

Heaters of this type, properly arranged, add about 150° to the heat of the feed water and are specially adapted for use with condensing engines of large power which deliver the water at about 100°; in this case the temperature of the feed water will be about 250°, so that if it enters the economisers at a normal temperature of, say 62° it will be raised to about 212°.

The cost of these economisers cannot be ascertained until the number and arrangement of tubes, tube scrapers, &c. have been determined, but the following information may be useful when arranging for the erection of this type of water heater.

Each heater tube, including the top and bottom chamber, contains about 6 gallons and one tube is required for each 3 I.H.P. The width of chamber or flue requisite for each group of tubes is as follows :—

| | | | | | |
|---|---|---|---|---|---|
| Number of tubes (in width) .. | 4 | 5 | 6 | 8 | 10 |
| Internal width of flue .. | 3ft. 4in. | 4ft. | 4ft. 8in. | 6ft. | 7ft. 4in. |

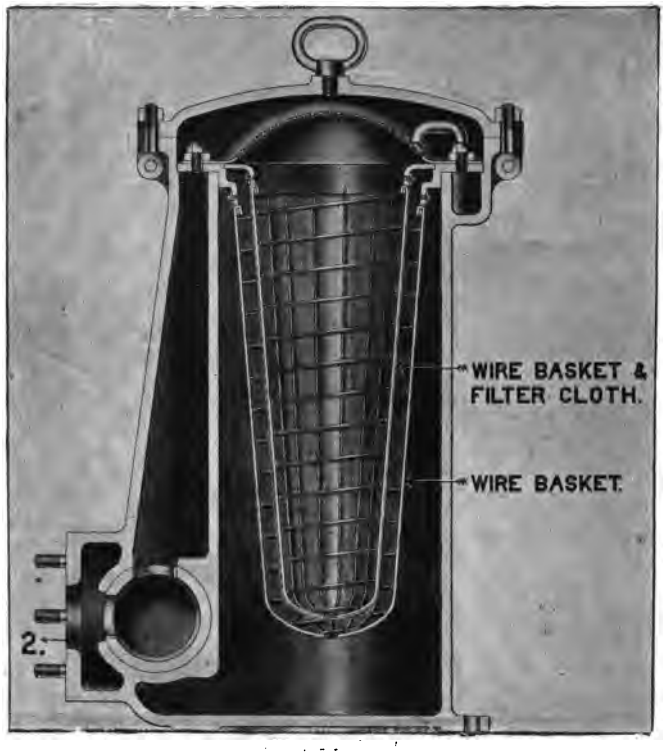



Fig. 1541.

**FEED WATER FILTERS,** illustrated by Fig. 1541, remove impure and solid matter from feed water and are made of various capacities in addition to those mentioned below.

Filters on the principle, which is clearly indicated in the engraving, are also arranged horizontally to adapt them for the boiler power to be provided for, and for fixing in the space—frequently very limited—which is available ; the prices are the same for either the vertical or the horizontal arrangement.

The filter case is provided with a series of brass frames which carry the wire gauze and flannel, forming the filtering materials, over and between which the water passes during the process of filtration. A large bye pass cock (2) is provided for discharging the dirt which has accumulated and the cover is easily removed when the filter plates require to be cleaned or replaced.

PRICE OF FEED WATER FILTERS, Fig. 1541.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| To supply I.H P. .. .. | 300 | 500 | 1000 | 2000 | 4000 | 6000 | 8000 | 10000 |
| Price in cast iron .. .. | £15 | £20 | £30 | £50 | £100 | £130 | £150 | £170 |
| Ditto gun metal .. .. | £20 | £30 | £50 | £75 | £120 | £150 | £180 | £200 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**WATER FILTRATION, PURIFICATION, AND SOFTENING** in large quantities for factory and domestic use, vide these subject on pages 86—91 in Section VI.

**BOILER FEED WATER APPARATUS.**—The quantity of water supplied to the boiler, as is well known, should correspond as nearly as possible with that evaporated in producing the steam which has been used. Whether the feed pump shall be worked from the engine, as in the older types of comparatively slow working engines, or by a separate feed pump or injector, depends on several considerations but, in any case, duplicate or reserve feed apparatus should be provided. This is recommended by all Boiler Insurance Societies and is indispensable in countries where steam boilers are under Government supervision.

**Feed pump on engine.**– Within certain limits of power and speed and under many conditions the feed pump, which is usually included in the price of the engine, is what is habitually used, the duplicate feed being provided by a donkey pump or an injector.

**Steam (donkey) feed pumps.**—Illustrations, descriptions, and prices of various types will be found on reference to Section III. See also Fig. 1534 and prices.

**Injectors.**—Although many modifications of these most useful instruments have been introduced within the last few years there is but little difference in the principles of their construction; the causes of uncertainty in the action of the earlier forms of injectors have been so completely removed that those now referred to may be entrusted to any driver. Attention is also directed to the fact—well known but not always recognised—that the steam used in forcing the water into the boiler imparts its heat to the feed water and so effects a proportionate saving in the consumption of fuel.

**The injector**, Fig. 1542, is of class **A** type referred to in the list on the following page; the others—for which prices are given—vary from it in details but not sufficiently so to make it necessary that each class should be illustrated. Thus classes **H** and **I** have self-contained steam valve and back pressure valve, whilst **A** and **B** have the former but not the latter. The injector costs less than a pump to deliver a corresponding quantity, and having no parts in motion the wear and tear is very small and, as it is entirely independent of the engine, the boiler can be fed whilst the engine is standing, which is often a great convenience. The steam employed in working the injector is returned to the boiler in a condensed form, with the feed water, raising its temperature and tending to prevent unequal expansion.

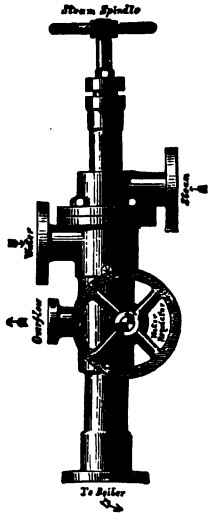


Fig. 1542.

**Fixing injectors.**—Care should be taken that the pipes connecting the injector with the boiler should not be of smaller diameter than that mentioned in the lists. Injectors **H** and **A** may be placed above or below the water supply, but **I** and **B** must be below or on the same level. They may be fixed either horizontally or vertically. The nut of the water regulating wheel must be kept moderately tight, to prevent the wheel being accidentally moved from its proper place. The water supply pipe should have a rose on the end of it, and care must be taken that this pipe is air tight. As an extra precaution, a back pressure valve should be placed on the delivery pipe, between the injector and boiler, also a regulating valve on the steam supply pipe; the latter is a necessity in class **I**. When it is desired to start feeding, open the valves or cock connecting the injector with the boiler, then open the water supply pipe to the extent required by the pressure in the boiler. The quantity of water fed may be increased by opening both the steam and water supplies.

## Prices of Injectors, Fig. 1542.

| Number or size in Millimetres. | PRICES. Class A. Entirely of brass. | Class A. Cast-iron case, brass spindle and nozzle. | Class B. Entirely of brass. | Class B. Cast-iron case, brass spindle and nozzle. | Class H. Entirely of brass. | Class H. Cast-iron case, brass spindle and nozzle. | Class I. Cast-iron case, brass spindle and nozzle. | Internal diameter of pipe in inches. | Number of Gallons delivered per hour at specified Steam Pressures. 10 lbs. | 20 lbs. | 30 lbs. | 40 lbs. | 50 lbs. | 60 lbs. | 70 lbs. | 80 lbs. | 90 lbs. | 100 lbs. | 110 lbs. | 120 lbs | 130 lbs. | 140 lbs. | 150 lbs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | £ s. | £ s. | £ s. | £ s. | £ s. | £ s. | £ s. | | | | | | | | | | | | | | | | |
| 2 | 3 15 | 3 10 | 2 15 | 2 12 | 3 15 | 3 10 | 3 0 | ¼ | 20 | 30 | 40 | 50 | 50 | 60 | 60 | 70 | 70 | 80 | 80 | 80 | 90 | 90 | 90 |
| 3 | 4 0 | 3 15 | 3 0 | 2 17 | 4 10 | 4 0 | 3 10 | ⅜ | 50 | 70 | 90 | 110 | 120 | 140 | 150 | 160 | 170 | 180 | 180 | 190 | 200 | 210 | 210 |
| 4 | 5 15 | 4 10 | 3 18 | 3 5 | 5 15 | 5 0 | 4 0 | 1 | 100 | 140 | 170 | 200 | 220 | 240 | 260 | 280 | 300 | 310 | 330 | 340 | 360 | 370 | 390 |
| 5 | 6 5 | 4 15 | 4 10 | 3 10 | 6 15 | 6 0 | 4 10 | 1 | 150 | 220 | 270 | 310 | 350 | 380 | 410 | 440 | 470 | 490 | 520 | 540 | 560 | 580 | 600 |
| 6 | 8 15 | 6 10 | 6 0 | 4 5 | 8 15 | 7 0 | 5 0 | 1¼ | 220 | 320 | 390 | 450 | 500 | 550 | 590 | 640 | 670 | 710 | 750 | 780 | 810 | 840 | 870 |
| 7 | 9 5 | 7 10 | 6 15 | 4 16 | 10 0 | 8 0 | 6 0 | 1¼ | 340 | 430 | 530 | 610 | 680 | 750 | 820 | 870 | 920 | 970 | 1,020 | 1,060 | 1,110 | 1,150 | 1,190 |
| 8 | 12 0 | 8 15 | 8 5 | 6 0 | 12 10 | 9 10 | 7 0 | 1½ | 400 | 560 | 690 | 800 | 890 | 980 | 1,060 | 1,130 | 1,200 | 1,270 | 1,330 | 1,390 | 1,450 | 1,500 | 1,550 |
| 9 | 13 0 | 9 15 | 9 5 | 7 0 | 14 0 | 11 0 | 8 0 | 1½ | 500 | 720 | 880 | 1,010 | 1,130 | 1,240 | 1,340 | 1,440 | 1,520 | 1,610 | 1,680 | 17,60 | 1,830 | 1,900 | 1,970 |
| 10 | 15 0 | 11 15 | 10 10 | 8 5 | 16 10 | 12 10 | 9 0 | 2 | 620 | 880 | 1,080 | 1,250 | 1,420 | 1,540 | 1,660 | 1,770 | 1,930 | 1,980 | 2,080 | 2,170 | 2,290 | 2,350 | 2,430 |
| 11 | 16 0 | 12 15 | 11 10 | 9 5 | 18 0 | 14 0 | 10 0 | 2 | 760 | 1,070 | 1,310 | 1,520 | 1,700 | 1,860 | 2,010 | 2,150 | 2,280 | 2,400 | 2,520 | 2,630 | 2,740 | 2,840 | 2,940 |
| 12 | 19 0 | 13 15 | 12 15 | 10 10 | 20 0 | 16 0 | 12 0 | 2¼ | 900 | 1,280 | 1,560 | 1,830 | 2,060 | 2,210 | 2,390 | 2,560 | 2,710 | 2,860 | 3,030 | 3,130 | 3,260 | 3,380 | 3,500 |
| 13 | 22 0 | 15 15 | 15 0 | 12 15 | 24 0 | 18 0 | 14 0 | 2¼ | 1,060 | 1,500 | 1,830 | 2,100 | 2 340 | 2,600 | 2,800 | 3,000 | 3,180 | 3,350 | 3,500 | 3,650 | 3,850 | 3,950 | 4,040 |
| 14 | 26 0 | 18 0 | 18 0 | 14 10 | 27 0 | 20 0 | 16 0 | 2½ | 1,230 | 1,740 | 2,000 | 2,450 | 2,730 | 3,000 | 3,200 | 3,450 | 3,650 | 3,890 | 4,050 | 4,250 | 4,450 | 4,650 | 4,790 |
| 15 | 28 0 | 19 10 | 21 0 | 16 0 | 30 0 | 22 0 | 18 0 | 2½ | 1,400 | 1,990 | 2,400 | 2,800 | 3,150 | 3,460 | 3,740 | 4,000 | 4,240 | 4,470 | 4,690 | 4.900 | 5,090 | 5,200 | 5,400 |
| 16 | 31 0 | 21 15 | | | 32 0 | 23 0 | | 2¾ | 1,600 | 2,270 | 2,750 | 3,200 | 3,600 | 3,940 | 4,250 | 4,550 | 4,850 | 5,080 | 5,350 | 5,570 | 5,800 | 6,020 | 6,220 |
| 17 | 34 0 | 23 10 | | | 35 0 | 25 10 | | 2¾ | 1,800 | 2,560 | 3,120 | 3,620 | 4,050 | 4,450 | 4,800 | 5,130 | 5,450 | 5,740 | 6,020 | 6,290 | 6,540 | 6,790 | 6,840 |
| 18 | 37 0 | 26 0 | | | 38 0 | 28 0 | | 2¾ | 2,030 | 2,870 | 3,500 | 4,060 | 4,540 | 4,990 | 5,380 | 5,760 | 6,110 | 6,430 | 6,750 | 7,050 | 7,340 | 7,630 | 7,920 |
| 19 | 40 0 | 29 0 | | | 41 0 | 31 0 | | 2¾ | 2,260 | 3,200 | 3,900 | 4,520 | 5,050 | 5,560 | 6,000 | 6,410 | 6,800 | 7,170 | 7,329 | 7,860 | 8,180 | 8,490 | 8,800 |
| 20 | 44 0 | 32 0 | | | 45 0 | 34 0 | | 3 | 2,500 | 3,550 | 4,340 | 5,000 | 5,600 | 6,160 | 6,650 | 7,110 | 7,540 | 7,950 | 8,340 | 8,700 | 9,060 | 9,400 | 9,740 |

**The nominal horse power** of stationary boiler, fed with fresh water, which the Injector will supply is found by omitting the last figure in the above table of gallons, thus:—

A number 6 Injector with 80lbs. steam pressure will feed a boiler of 64 nominal horse power, or one of 50 horse power with 50lbs. steam pessure, and so on.

For Marine boilers fed with sea water, the Injector, should be one or two sizes larger to allow the margin necessary for blowing off brine, &c.

For description of the different types of Injectors, see the preceding page.

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

Fig. 1543.

**THE UNIVERSAL INJECTOR**, Fig. 1543, works with steam at any pressure between 5 lbs. and 150 lbs. per square inch and (if necessary) will lift cold feed water from a depth not exceeding 24 ft. or—with an overhead supply any of these injectors will feed water at temperatures up to 150 degrees.

Fig. 1543 represents what is called a "right hand" injector, that is to connect with the boiler on right, but the branches are reversed for fixing to the opposite side, and either right or left hand will be sent as may be required. If orders are cabled, the word "right" or "left" before or after the code word given in the index will suffice to insure correct execution.

If instruments are required to fulfil conditions differing from those referred to in this description and the accompanying list, the points of deviation should be specified and in all cases open to doubt it is desirable that information should (if possible) be given as to the working pressure of steam, the temperature of the feed water and the quantity required per hour; also the height of lift (if any) or the height, in feet of the feed water supply above the point of delivery to the boiler.

The duty, given in the following table, in gallons delivered per hour, is based on a steam pressure of 60 lbs. per square inch. If loose flanges are required the extra cost, including bolts, is about 10 per cent. Injectors with brass cases are made with unions and those in iron with flanges as shown.

Special quotations will be given for injectors of larger capacity than 1250 gallons per hour.

PRICES OF UNIVERSAL INJECTORS, Fig. 1543.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capacity per hour galls | 92 | 164 | 260 | 370 | 510 | 660 | 830 | 1250 |
| Diameter of pipes inches | ½ | 1 | 1¼ | 1½ | 1½ | 1½ | 1¾ | 2 |
| Price with brass case .. | £4 10 | £5 10 | £8 10 | £9 10 | £11 10 | £12 10 | £15 | £17 |
| Ditto iron do. .. | .. | .. | £6 | £7 | £8 | £9 | £10 | £12 |

The cost of packing for shipment and delivery f.o.b. is usually about 5 per cent.

Fig. 1544.

**THE GEIPEL STEAM TRAP**, Fig. 1544, is extremely accessible and so compact that it can be fixed on the bed plate of the engine. The lower pipe is of brass and is connected to the steam pipe; the upper pipe is of iron and forms the discharge, the two making the two sides of an isosceles triangle with a valve at the apex. When cold, the apex is drawn down so that the valve is fully open and the water is discharged, but so soon as steam enters the brass pipe it expands and causes the valve to close. The valve can be adjusted by a screw to blow off at any pressure or it is opened by pressing the lever when it is desired to blow through.

**The A size** is suitable for drying the jackets and cylinders of engines of any power. The valve is ⅜-in. diameter and the inlet may be of any diameter from ⅜ to 1½ in.

**The B size** will effectually trap a range of heating pipes. The valve is ½-in. diameter and the inlet may range from ¾ to 2 in.

**The C size** will drain a large system of pipes from several points. The valve is ⅝-in. diameter and the inlet may vary from 1 to 2½ in. diameter.

PRICES OF THE GEIPEL STEAM TRAP, Fig. 1544.

| Size.. .. .. .. .. .. .. | A | B | C |
|---|---|---|---|
| Price of trap .. .. .. .. .. | £2 5 0 | £3 3 0 | £4 10 0 |

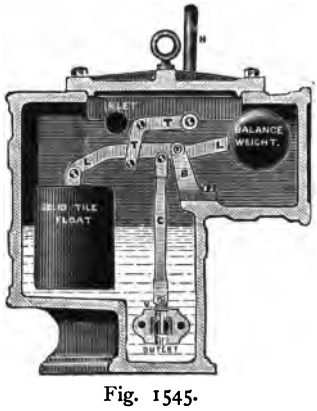



Fig. 1545.


Fig. 1546.

**HIGH PRESSURE STEAM TRAPS.**—Fig. 1545 illustrates a simple and efficient mechanical arrangement which automatically ejects any water which may have condensed in pipes, engine cylinders, &c, and acts more rapidly than appliances for similar purposes which work by contraction and expansion.

The valves are opened or closed by the handle **H** for blowing through at starting or for clearing the valve seats of any grit which may have been deposited on them. The ball which counterbalances the float is adjustable on the lever **L** and is regulated to cause the float to begin to rise at any point desired to discharge the condensed water through the equilibrium valve **V**; practically the only part subject to wear is the hardened knife edge which supports the lever **L**, as in a scale beam. The air in the apparatus is discharged by a pet cock or by an automatic air relief valve as desired.

The large experience gained in the use of these steam traps in connection with engines for factories, electric lighting installations and other purposes have proved that they are sensitive and reliable in action and durable.

The size of trap is determined by the diameter of pipe to which it will be connected and purchasers should state the pressure of steam it will be required to work with.

PRICES OF STEAM TRAPS, Fig. 1545.

| Diameter of steam pipes inches | ½ | ¾ | 1 | 1½ | 2 | 2½ | 3 |
|---|---|---|---|---|---|---|---|
| Price of trap .. .. .. | £6 | £6 15 | £7 | £8 5 | £10 15 | £13 | £17 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**STEAM DRYERS AND SEPARATORS** of the type Fig. 1546, intercept and remove water or dirty matter carried from the boilers and ensure a supply of dry and clean steam to the cylinders; they are made of all diameters from 1 in. to 15 in. and the diameter of the separator should in all cases be the same as that of the steam pipe to which it will be connected.

The steam enters the separators at the branch shown in the engraving on the right hand and purchasers should state whether the steam will be from that or from the opposite side. The interior has two compartments with a central division plate in which is an opening of ample area covered by guaze of any desired fineness; this separates the moisture and impurities from the steam and deposits each in the compartment (above mentioned) destined to receive them. The accumulations are cleared out from time to time by opening a blow off cock supplied for that purpose, the clean water being returned to the boiler but slightly reduced in temperature.

Prices for separators of sizes other than those mentioned in the subjoined list will be given when desired.

PRICES OF STEAM DRYERS AND SEPARATORS, Fig. 1546.

| Diameter .. inches | 1 | 1½ | 2 | 3 | 4 | 6 | 8 | 10 | 12 |
|---|---|---|---|---|---|---|---|---|---|
| Price of separator .. | £3 | £4 5 | £5 10 | £7 10 | £8 10 | £11 10 | £15 | £19 | £22 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**OIL EXTRACTORS AND SEPARATORS** of the type Fig. 1547 separate greasy matter from feed water on its passage from the injector or pump to the boiler.

Fig. 1547.

Several instances have occurred in the Writer's experience in which a large and (at that time) unaccountable rise in the consumption of fuel has been observed, but not immediately attended to; the result was, in one case the early collapse of two boiler flues, both of which had to be replaced. On investigation it was found that oil carried over in the feed water and deposited on the flue plates, was the direct cause of both these evils.

The feed water is pumped through the apparatus shown in section in Fig. 1547 and in its passage from the inlet to the outlet branch it is compelled by the two series of partitions to assume a wavy upward and downward course. The result of this is that, by reason of the specific gravity of the greasy matter being lower than that of water, the former rises in globules and is collected in the upper chamber from which it is removed—usually by a drip pipe into a receiver—and is ready for further use; the water, being heavier than the oil, falls to the bottom of the chamber and is syphoned back for discharge through the main outlet. The following prices are for the apparatus in cast iron and the diameters of pipes are those of the feed water pipes.

PRICES OF OIL SEPARATORS, Fig. 1547.

| Diameter of pipe .. inches | 1½ | 2 | 2½ | 3 | 3½ | 4 |
|---|---|---|---|---|---|---|
| Price of separator .. .. | £15 | £17 | £18 | £20 | £23 | £25 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**WATER COOLING APPARATUS.**—Fig. 1547b illustrates one arrangement of Klein's system which is successfully employed for cooling water for **Condensors,** and for use in **Breweries, Distilleries, Ice Factories, Sugar Works,** &c., where an ample supply of water at a low temperature is valuable, if not absolutely essential.

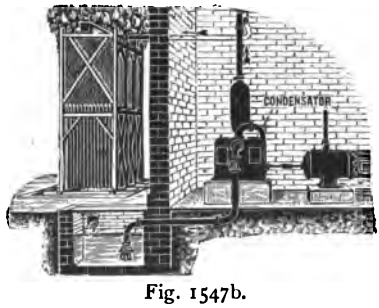



Fig. 1547b.

The apparatus consists of a timber or metallic frame, usually about 16 feet high, in which a number of wood plates fixed vertically form a large cooling surface. The water flows over these plates; if space is limited, a fan is used and the cooling area largely reduced.

**The cost of working** is limited to that of delivering the heated water to the top of the cooler—an item too small to be worth consideration.

**For condensing engines** the pump which forms part of the engine is easily arranged to raise the water to the cooler.

**For breweries** and many other works, the advantage of reducing the temperature of the water to about 20 degrees below that of the atmosphere will be easily recognised.

The first of the following tables give results which have been obtained, and the second indicates the quantities of water cooled to medium and lowest temperatures, also the approximate H.P. of engines for which each size is suitable.

| | | | | |
|---|---|---|---|---|
| Temperature of air .. .. .. | degrees | 86 | 68 | 46 |
| ,, of hot water .. .. | ,, | 71 | 68 | 60 |
| ,, of cooled water .. .. | ,, | 59 | 53 | 39 |
| Pressure in ice machine compressor .. | atmos. | 7.8 | 7. | 6.5 |
| Loss of water .. .. .. .. | per cent. | 5 to 7 | 4 | 2 to 3 |

If space is limited, a sketch showing the floor area and height available should be furnished, together with details of the quantity to be cooled in a given time, the temperatures, &c.

PRICES OF WATER COOLERS, Fig. 1547B.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| For compound engines of about h.p. | 80 | 125 | 200 | 340 | 440 | 520 | 600 |
| Steam condensed per hour .. lbs. | 1600 | 2400 | 4000 | 6400 | 8800 | 10400 | 12000 |
| Water cooled, med. temp. per hr. gall. | 4800 | 7200 | 12000 | 19200 | 26400 | 31200 | 36000 |
| ,, ,, lowest ,, ,, ,, | 1900 | 2900 | 4800 | 7600 | 10500 | 12500 | 14400 |
| Price of cooler .. .. .. | £66 | £93 | £155 | £255 | £330 | £400 | £465 |

**WATER PURIFIER AND SOFTENER.**—Many arrangements have been devised for removing the scale forming elements in feed water, the well known evil effects of which are referred to at page 46. The automatic process (Brunn's patent), now briefly described, removes all Lime, Magnesia, Oil, &c., at a nominal cost, and admits of water being used which—without purification—would be quite unfit for boiler supply and other purposes.

**The Apparatus** consists of a wrought iron vessel which contains all appliances for purifying and softening the water and has merely to be connected respectively with the foul water supply, and the pure water delivery pipes.

**The Chemicals** used are inexpensive and adjustments are provided for regulating the supply requisite for treating different kinds of water. The action of the apparatus causes the sedimentary matter to deposit at the bottom and the water is further purified by being filtered through wood pulp. The sediment is removed at intervals of a few weeks and—at the same time—the wood pulp filtering materials may be cleansed for further use.

**Analysis.**—Ordinary analyses do not always give the data required for this process and, to insure the removal of practically all scale forming matter, a sample of one or two gallons of the water to be treated should be sent for special analysis.

**Information required.**—This should include:—(1) The purpose for which the water is to be used; (2) The quantity to be treated in a given time, or the quantity of coal used under the boilers, per hour; and (3) Whether the water will be heated to (say) 130° fahr. before it enters the purifier.

**The sizes of purifiers.**—The apparatus is made of capacities suitable for treating from 50 to more than 5000 gallons per hour, with or without feed water heater and feed water tank, and the prices range from about .. .. .. .. .. .. .. £20 to £450.

**STEAM ENGINE SPEED REGULATOR.**—The apparatus Fig. 1548a, is attached in a few hours to the throttle valve of an existing engine and will regulate the speed, and maintain a uniform number of revolutions, under widely varying loads.

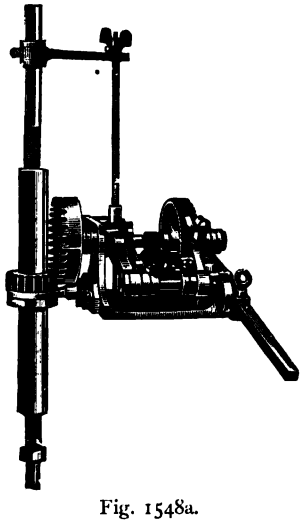


Fig. 1548a.

This result is obtained by adjusting a nut on the valve rod, actuated by the regulator, to give more or less steam at the instant that the load varies or the pressure of steam in the boiler rises or falls. In a modified form it can also be arranged to act on the cut off of an expansion valve.

The absence of delicate working parts is a strong recommendation and the application of this regulator to engines of all kinds, driving cotton, silk, woollen, electric light installations, &c., including those with Corliss valve gear, has invariably been successful in preventing over-running, which is always inconvenient and—frequently—a cause of absolute loss.

PRICES OF ENGINE SPEED REGULATORS, Fig. 1548A.

| | | | | | |
|---|---|---|---|---|---|
| I.H.P. of engine about | 50 | 250 | 650 | 900 |
| Price of regulator .. | £10 | £15 | £20 | £25 |

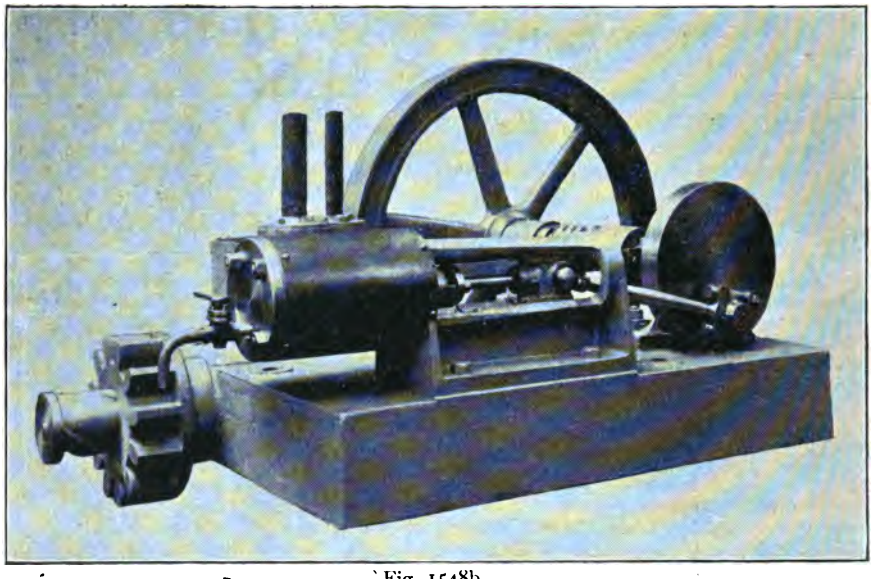


Fig. 1548b.

**BARRING ENGINES** of the type Fig. 1548b should form part of the equipment of all engine rooms where the main engine exceeds 200 horse power. That illustrated is used in connection with a compound condensing engine, Fig. 1503, of 250 horse power and operates in the following manner :—

The pinion slides on the spiral feather shown in the engraving and starts the main engine by engaging with the spur ring on the rim of flywheel, or bolted to it; but so soon as the circumferential velocity of the flywheel exceeds that of the pinion, the latter is automatically "screwed" out of gear and remains so until the main engine is again to be started.

**The prices** of these engines, complete as shown, range from about .. £70 to £100.

**STEAM ENGINE INDICATORS.**—The original indicator invented and used by James Watt has undergone many modifications to adapt the instrument to give—at the higher speeds and pressures which have gradually superseded those of the Watt period—a graphic record of the cycle of operations in the engine cylinder, the setting of valves, &c., but reference to several types may be omitted and the present remarks limited to three well known instruments which are illustrated in Figs. 1548 to 1550.

Fig. 1548.

**The Richards Indicator** illustrated by Fig. 1548 gives good diagrams at speeds not much exceeding 150 revolutions per minute and is still largely used. The stroke of the piston is $\frac{3}{8}$ of an inch and the vertical motion of the pencil is 4 to 1; beyond the speed above mentioned the oscillation of the pencil introduces errors which do not appear when one of the newer types (Fig. 1549 or 1550) is used. The springs and scales provided are for English or metric measure, as may be desired.

The price of a Richards nickel plated indicator with one spring and scale, stop cock and accessories, all in a neat case is £7 10 0

Extra springs with scales $\frac{1}{8}$ to $\frac{1}{80}$ or their equivalent in metric measure, each £0 10 0

Extra cocks .. .. .. .. .. .. .. ,, £0 10 0

Blocks of metallic diagram paper .. .. .. .. ,, £0 2 6

**The Crosby Indicator,** Fig. 1549.—By modifications, principally in the pencil arm and the attachments with the piston, this instrument is adapted for indicating the high speed engines now so generally employed and many perfectly clear and measurable diagrams have been taken at speeds up to and including 400 revolutions per minute. The stroke of the piston is $\frac{3}{8}$ of an inch and that of the pencil arm is 6 to 1 instead of 4 to 1 as in the Richards indicator.

Fig. 1549.

The springs for English measures are made Nos. 4, 8, 10, 12, 16, 20, 24, 30, 40, 50, 60, 80, 100, 120, 150 and 180, and those for metric measures 2, $2\frac{1}{2}$, 3, 4, 5, 6, 7, 8, 10, 12, 15, 16, 20, 30, 45, 60.

As is known to all who are familiar with the use of the indicator the number of the spring for English measure represents the pressure in pounds per square inch required to compress it sufficiently to move the pencil vertically through one inch on the diagram, whilst the number for metric measure represents the height in millimetres to which the pencil is raised by a pressure of 1 kilogramme per square centimetre.

It is recommended that the traverse of pencil, with the Crosby indicator shall not exceed $1\frac{3}{4}$ inch or about 45 millimetres. A special pencil is required for a gas engine indicator.

The price of a Crosby nickel plated indicator with one spring and scale, a stop cock, tools, 50 sheets of metallic paper, &c., is .. .. .. .. .. £9 0 0

Extra springs with scale .. .. .. .. .. each £0 10 0

Ditto three-way cock .. .. .. .. .. ,, £1 8 0

Fig. 1550

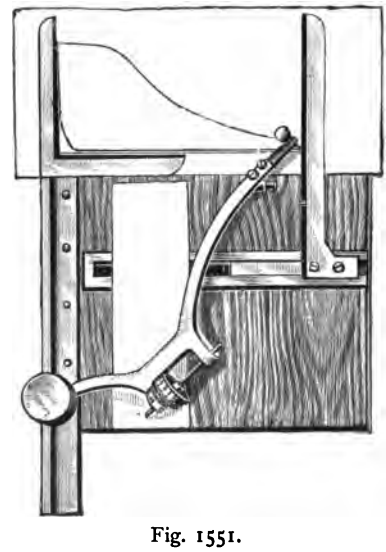


Fig. 1551.

**The Tabor indicator,** Fig. 1550 —Several improvements have been introduced in this most recent type of indicator, amongst which may be mentioned those eliminating over pressure or other disturbing influence on the movement of the pencil, and those in the attachments made with a view of this being the handiest and most accurate instrument, even at the highest speeds.

The stroke of the piston is ·65 in.—about 16 millimetres and the movement of the arm is in the ratio of 5 to 1. The springs are made of all usual strengths and for English or metric scale, as desired.

The price of the Tabor nickel plated indicator with one spring and scale, two indicator cards, cord adjuster, tools and accessories is .. .. .. .. £12 10 0
Extra springs with scale .. .. .. .. .. each £0 15 0
Three way cock for taking diagrams from both ends of the cylinders without moving the indicator .. .. .. .. £1 15 0
Indicator cord per hank .. .. .. .. .. £0 2 6
Metallic or plain diagram paper per packet .. .. .. .. £0 2 6

**Diagram averager.**—The instrument Fig. 1551 has been devised for quickly and accurately determining the average effective pressure shown by a diagram, without calculation and without risk of error.

As will be seen from the instructions sent with each averager, it is quite easily manipulated and is of great value where a number of diagrams have to be computed, or for checking those which have been determined by calculation.

The price of a nickel plated diagram averaging instrument is .. .. £6 5 0
If in polished walnut case .. .. .. .. .. £7 10 0
The cost of packing Figs. 1548 to 1551 for shipment and delivery f.o.b. is about 5 per cent.

**PRESSURE RECORDER.**—This instrument graphically records the date, the time of day, and the duration of every change in steam pressure which takes place within 24 hours.

The mechanism is enclosed in a circular case and is adapted for all pressures up to 200 lbs. per square inch.

Fig. 1552.

The price of the recorder, with dial 6¾ in. diameter, supply of paper for a year, ink and filler is .. £8 0 0

**WATER OR STEAM PRESSURE RECORDER,** Fig. 1552, for indicating by dial the pressure of water or steam and recording it by diagram at every period during 24 hours. The apparatus is complete with timepiece, pressure gauge with a dial 7 in. diameter, drum and attachments for the diagram paper and cock and union for connection with the water of steam pressure pipe. These are contained in a neat metallic case and afford a complete record of uniformity—or otherwise—in performance.

The price of the recorder marked in lbs and feet for water pressure is £14 10 0
For steam pressure the record is made in lbs. per square inch or in kilogrammes per square centimetre and the price is .. .. £12 10 0

**INDICATORS** for various purposes such as ascertaining depths of liquids, tally counting, measuring the thickness of pipes or other articles of irregular section, the length of rolls of paper, cloth, distances traversed by vehicles, &c., range in price each from about £2 to £5.

**PYROMETERS** for determining the temperature of boiler fires, gases in flues, furnace hot blast, tuyeres, &c., are arranged for these purposes and for several others not enumerated.

**Flue testing pyrometers**, graduated to 1500° fah. or to the equivalent in degrees centigrade, with dial 7 in. diameter and stem about 4 ft. long, price .. .. £4 4 0

**Locomotive and marine engineer's pyrometer** with dial 4in. diameter, price .. £5 10 0

**Drying stove, &c. pyrometer** graduated to 700° fah. and adapted for taking the temperature in ovens, stoves for drying tea and other products, price .. .. £2 10 0

**Blast furnace pyrometer** with screw adjustment to the indicating lever and pointer registering the maximum heat, price .. .. .. .. .. £6 6 0
If without the maximum pointer .. .. .. .. .. £5 5 0

**BLAST PRESSURE GAUGES.**—Amongst the numerous devices for ascertaining the pressure of blast to furnaces, the open column mercurial gauge may be mentioned as quite satisfactory. The scale is graduated in ounces per square inch and in inches water column up to 27. The price is .. .. .. .. .. .. .. £2 2 0

**STEAM AND FEED WATER THERMOMETERS** indicating the temperature of the water in a boiler or of feed water from the economizer, hot well, &c., marked in degrees fah. or centigrade and in pressures per square inch or centimetre, corresponding with the temperatures.
Price with circulating elbow, &c. .. .. £2 2 0
Spare thermometer glasses and scales, each .. £0 8 0

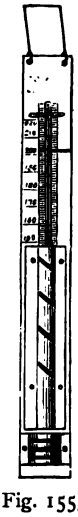


Fig. 1553.

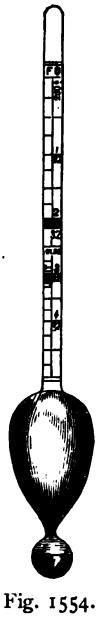


Fig. 1554.

**Oil testing thermometers** Fig. 1553.—This instrument is adapted for taking the temperature of oils, bearings, &c. up to 220° fah.
The price of the thermometer is .. .. £0 12 6
Spare thermometers, each .. .. .. £0 8 6

**Salinometers.**—Fig. 1554 represents the instrument in general use for indicating the density of salt water in steam boilers and the point at which the saline matter should be blown off and replaced by fresh water, to avoid incrustation and consequent waste of fuel. The markings on the stem indicate the density of the water tested, 0 being pure water and $\frac{1}{32}$, $\frac{2}{32}$, &c. that it contains one, two or more parts of saline matter, to 32 of water at a temperature of 200°.
The price of the salinometer, Fig. 1554 in glass is.. £0 5 6
Ditto ditto in gilt metal .. £0 18 0
Or if in German silver box .. .. .. £1 1 0

**How's Salinometer** is made in gun metal and brass and is attached to the boiler for ascertaining at any moment, the specific gravity of the water in the boiler. The instrument is complete with metal salinometer, thermometer and lamp, gun metal cock, unions and valves and the price is .. .. .. .. £8 8 0

**Gamble's and Saunder's salinometers** each differ in arrangement from that last referred to, but they are used for the same purpose and are made at the same price.

**ENGINE COUNTERS OR SPEED INDICATORS** for registering numbers of revolutions or of oscillating or reciprocating motions. The mechanism is enclosed in a case and is arranged to count to the right or the left, or in either direction and with or without setting back motion, as desired.

PRICES OF ENGINE COUNTERS.

| Number of dials .. .. | 4 | 5 | 6 | 7 |
|---|---|---|---|---|
| To register up to .. .. | 10,000 | 100,000 | 1,000,000 | 10,000,000 |
| Price of counter .. .. | £2 13 6 | £3 | £3 7 6 | £3 15 0 |
| Ditto to set back .. .. | £3 15 0 | £4 | £4 10 0 | £5 0 0 |

**POCKET COUNTER** in case, to register up to 5,000 revolutions .. £0 7 6
Ditto ditto ditto ditto 10,000 ditto .. £0 12 6

Fig. 1555.

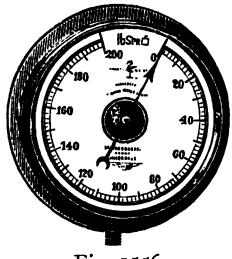


Fig. 1556.

Fig. 1557.

**STEAM PRESSURE AND VACUUM GAUGES,** Figs. 1555 and 1556, are made on Bourdon's principle and are enclosed in brass cases; the dials are marked in lbs. per square inch or in atmospheres, or in both, as desired. The gauges are supplied at the undernamed prices, for all pressures up to 300 lbs. per square inch.

PRICES OF PRESSURE AND VACUUM GAUGES, Figs. 1555 and 1556.

| Diameter of dial .. inches | 3 | 4 | 5 | 6 | 7 | 8 | 9½ | 12 |
|---|---|---|---|---|---|---|---|---|
| Price of gauge .. .. each | 15/- | 17/- | 19/6 | 22/- | 25/- | 35/- | 45/- | 55/- |
| ,, with bevelled glass ,, | 15/9 | 18/- | 21/- | 23/9 | 27/- | 38/6 | 50/- | 62/6 |
| ,, duplex test gauges ,, | 29/6 | 30/6 | 36/- | 41/- | 46/6 | 51/- | .. | .. |

**Price of fittings.**—Cocks 2/6, control cocks 4/6, iron syphon 1/6, brass syphon with gun metal cock ⅜-in. 4/6, ½-in. 6/3, pendant syphon with screwed end 15/-, with flange 16/6.

**HYDRAULIC GAUGES,** Fig. 1557, in lockup brass cases, with maximum pressure indicator and loose connecting nuts, for any pressure up to 10 tons per square inch and marked in lbs. per square inch or kilogrammes per square centimetre, or both.

PRICES OF HYDRAULIC GAUGES, Fig. 1557.

| Diameter of dial .. .. .. .. .. inches | 5 | 6 | 7 |
|---|---|---|---|
| Price of gauge .. .. .. .. .. .. | 50/- | 60/- | 70/- |

The cost of packing for shipment and delivery f.o.b., is about 5 per cent.

**SPRING BALANCES** in cylindrical cases, with screw and nut and marked on the draw out bar, or on the outer or inner tube in lbs. or kilogrammes, as desired.

PRICES OF SPRING BALANCES, Fig. 1560.

| Range .. .. .. inches | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|
| Strength 100 lbs. .. .. | 23/- | 25/- | 27/- | 29/- | 31/- | 33/- | 35/- |
| ,, 120 ,, .. .. | 25/- | 27/- | 29/- | 31/- | 33/- | 35/- | 37/- |
| ,, 130 ,, .. .. | 26/- | 28/- | 30/- | 32/- | 34/- | 36/- | 38/- |
| ,, 140 ,, .. .. | 27/- | 29/- | 31/- | 33/- | 35/- | 37/- | 39/- |
| ,, 150 ,, .. .. | 29/- | 31/- | 33/- | 35/- | 37/- | 39/- | 41/- |
| ,, 170 ,, .. .. | 31/- | 33/- | 35/- | 37/- | 39/- | 41/- | 43/- |
| ,, 200 ,, .. .. | 36/- | 38/- | 40/- | 42/- | 44/- | 46/- | 48/- |

**SAFETY VALVES**—As it is impossible to refer to even a fair proportion of the types in general use, the illustrations must be limited to the valves Figs. 1558—1560.

Fig. 1558.

Fig. 1559.

Fig. 1560.

**WEIGHTED LEVER VALVES,** Fig. 1558, have cast iron bodies with flanges for securing to the boiler and are fitted with gun metal seatings, valves and pointed spindles, wrought iron levers and adjustable balls.

PRICES OF WEIGHTED LEVER VALVES, Fig. 1558.

| Internal diameter .. inches | 1½ | 2 | 2½ | 3 | 3½ | 4 |
|---|---|---|---|---|---|---|
| Price of single valve .. | £1 16 | £2 5 | £2 10 | £3 | £3 10 | £4 |
| ,, double ,, .. | £3 4 | £3 16 | £4 6 | £5 | £5 15 | £6 18 |

**SPRING SAFETY VALVES.**—The Crosby valve, Fig. 1559, is neat and compact and may be relied upon to open freely at the pressure for which it is set, and to close with about 2 lbs. reduction in pressure.

The lever can be at the top instead of at the side, as shown and the setting of the valve may be adjusted by loosening the lock nut and turning the screw up or down, to increase or diminish the pressure as desired. Every valve is tested under steam pressure and regulated to that desired, before delivery; the prices are given of the two types in general use; these discharge at the top, or at the side for conducting the waste steam away, as is frequently desired for yachts, steam launches, &c.

The valves referred to are made of gun metal and the connection with the boiler is by screw as shown or by flange if preferred; valves with iron cases for large stationary or marine boilers, are subject to special estimate.

PRICES OF SPRING SAFETY VALVES, Fig. 1559.

| Internal diameter .. .. .. inches | 1 | 1¼ | 1½ | 2 |
|---|---|---|---|---|
| Nominal horse power boiler .. .. | 10 | 20 | 30 | 40 |
| Price of valve with top outlet .. .. | £1 4 0 | £1 10 0 | £2 2 0 | £3 0 0 |
| ,, ,, side ,, .. .. | £1 8 0 | £2 0 0 | £2 16 0 | £3 12 0 |

The cost of packing for shipment and delivery f.o.b., is about 5 per cent.

Fig. 1561.

**FUSIBLE PLUGS** for boilers, Smith's or other type 1½ inch price 12/6, 2 inch 20/- each, spare caps 5/3 each, small plugs price 8/6, spare caps 3/3 each.

**STEAM WHISTLES.**—The ordinary type shown in Fig. 1561 is made in gun metal with ebony or brass handle and is screwed to iron gas tube thread. They are also made with self-closing valve and with spring valve and the prices of each kind, tested with steam at a pressure of 60 lbs. per square inch, is as follows, larger or smaller sizes or other types, will be supplied when desired.

PRICES OF STEAM WHISTLES.

| Diameter .. .. .. inches | 1½ | 2 | 2½ | 3 | 4 |
|---|---|---|---|---|---|
| Price of Fig. 1561 .. .. .. | 7/6 | 10/6 | 15/- | 18/6 | 35/- |
| ,, self closing .. .. | .. | 13/6 | 19/3 | 24/- | 33/- |
| ,, spring valve .. .. | .. | 12/6 | 17/6 | 21/- | 36/- |

PRICES OF ORGAN WHISTLES.

| Diameter .. .. inches | ¾ | 1 | 1½ | 1¾ | 2 | 2½ | 3 | 4 |
|---|---|---|---|---|---|---|---|---|
| Length .. .. .. ,, | 5 | 5½ | 8 | 8¾ | 11 | 12½ | 17½ | 20½ |
| Price .. .. .. .. | 8/- | 10/- | 20/- | 21/- | 26/- | 34/6 | 40/- | 95/- |

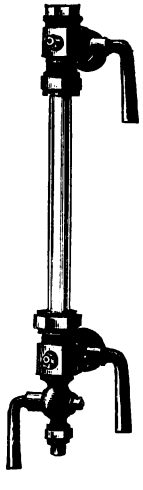


Fig. 1562.

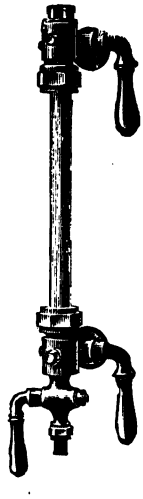


Fig. 1563.

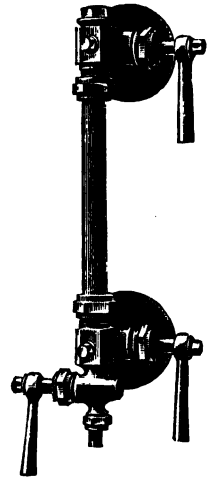


Fig. 1564.

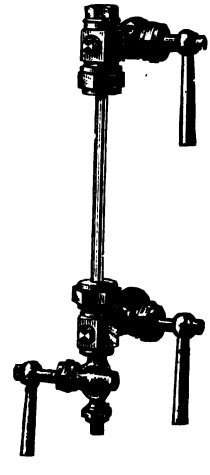


Fig. 1565.

**WATER GAUGES, GAUGE AND SNIFT COCKS.**—Figs. 1562 to 1565, represent only a few of the patterns made, but others, not illustrated, will be supplied when desired. These fittings are in polished gun metal with ebony or brass handles and are tested to a pressure of 200 lbs. per square inch; unless ordered with plain ends or with a special thread, the ends are screwed to gas tube thread of equal size.

The gauges Fig. 1563 of ⅜, ½ and ⅝-inch diameter are made with a steam whistle, at an extra cost of 5/-.

PRICES OF WATER GAUGES, Figs. 1562 to 1565.

| Diameter of gauge .. .. .. inches | ⅜ | ½ | ⅝ | ¾ |
|---|---|---|---|---|
| Price of Fig. 1562 with screwed ends, each | £0 13 0 | £0 15 0 | £1 0 0 | £1 4 6 |
| ,, ,, ,, flanged ,, ,, | £0 15 0 | £0 17 6 | £1 2 0 | £1 8 0 |
| ,, Fig. 1563 ,, screwed ,, ,, | £0 18 0 | £1 0 0 | £1 7 0 | £1 11 0 |
| ,, ,, ,, flanged ,, ,, | £1 0 0 | £1 2 6 | £1 10 0 | £1 14 0 |
| ,, Fig. 1564 ,, screwed ,, ,, | £1 1 0 | £1 2 0 | £1 8 0 | £1 13 0 |
| ,, ,, ,, flanged ,, ,, | £1 3 0 | £1 5 0 | £1 10 0 | £1 17 0 |
| ,, Fig. 1565 ,, screwed ,, ,, | .. | £1 10 0 | £1 16 0 | £2 2 6 |
| ,, Guard for glass .. .. ,, | £0 1 9 | £0 2 0 | £0 2 6 | £0 3 6 |

**PEDESTAL WATER GAUGES AND GAUGE COCKS,** fitted to a cast iron or polished gun metal standard, are subject to special quotation.

**CAST IRON WATER GAUGES** similar to Fig. 1564, but made in cast iron to resist the action of certain chemicals, for glasses ¾ or 1 inch diameter and with screwed or flanged ends, price each .. .. .. .. .. .. .. .. £2 5 0

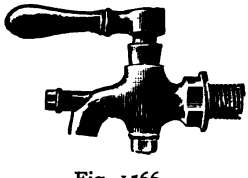


Fig. 1566.

Fig. 1567.

Fig. 1568.

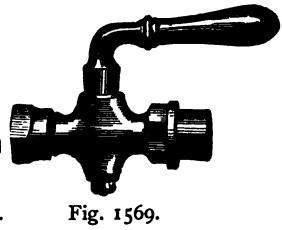


Fig. 1569.

Fig. 1570.

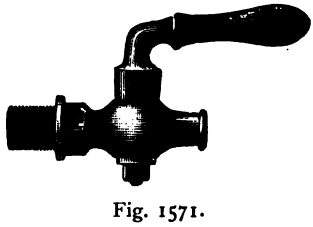


Fig. 1571.

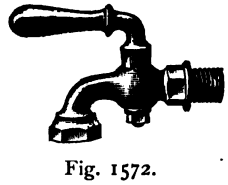


Fig. 1572.

PRICES OF GAUGE AND PET COCKS.

| Diameter.. .. .. inches | ¼ | ⅜ | ½ | ⅝ | ¾ | 1 |
|---|---|---|---|---|---|---|
| Price of Fig. 1566 .. .. | 3/4 | 3/7 | 4/2 | 5/3 | 6/7 | 10/5 |
| ,, ,, 1567 .. .. | 2/11 | 3/4 | 4/2 | 4/10 | 5/9 | 10/9 |
| ,, ,, 1568 .. .. | 1/8 | 2/7 | 3/5 | 4/5 | .. | .. |
| ,, ,, 1569 .. .. | 3/- | 3/4 | 4/3 | 5/- | 6/7 | 10/1 |
| ,, ,, 1570 .. .. | 2/1 | 2/11 | 3/5 | 5/4 | 6/8 | .. |
| ,, ,, 1571 .. .. | 1/8 | 2/9 | 3/4 | 4/3 | 5/8 | 8/3 |
| ,, ,, 1572 .. .. | 2/6 | 3/3 | 4/4 | 4/7 | 6/6 | 8/10 |

**GAUGE GLASSES.**—The white glasses referred to in the subjoined list are made of any length up to about 30 inches, and are those generally used.

**The "Beacon" glasses** show through the water, a broad red line which is visible by night as well as in day light.

PRICES OF WHITE GAUGE GLASSES.

| Length of glass .. .. inches | 12 | 15 | 18 | 21 | 24 | 30 |
|---|---|---|---|---|---|---|
| Price per dozen ⅜-in. diameter.. | 3/- | 3/9 | 4/6 | 5/3 | 6/- | 7/6 |
| ,, ,, ½ ,, ,, .. | 3/9 | 5/3 | 6/9 | 8/3 | 9/9 | 12/9 |
| ,, ,, ⅝ ,, ,, .. | 4/9 | 7/- | 9/3 | 11/6 | 13/9 | 18/3 |
| ,, ,, 1 ,, ,, .. | 5/9 | 8/9 | 11/9 | 14/9 | 17/9 | 23/9 |

**India rubber washers,** round or square section, price £0 6 0 per gross.

PRICES OF "BEACON" GAUGE GLASSES.

| Length of glass .. .. inches | 10 | 12 | 15 | 18 | 21 | 24 |
|---|---|---|---|---|---|---|
| Price per dozen ½-in. diameter.. | 7/3 | 7/6 | 8/6 | 10/- | 11/6 | 13/- |
| ,, ,, ⅝ ,, ,, .. | 7/6 | 7/9 | 9/- | 10/6 | 12/- | 13/6 |
| ,, ,, ¾ ,, ,, .. | 8/9 | 9/3 | 11/6 | 13/6 | 15/6 | 18/- |
| ,, ,, ⅞ ,, ,, .. | 9/6 | 10/6 | 13/6 | 16/6 | 19/6 | 22/6 |
| ,, ,, 1 ,, ,, .. | 11/6 | 12/- | 16/6 | 22/- | 27/- | 32/- |

Fig. 1573.

Fig. 1574.

Fig. 1575.

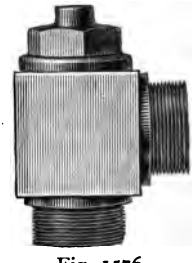


Fig. 1576.

**GUN METAL WHEEL STEAM VALVES** with cast iron hand wheels and tested to a pressure of 200 lbs. per square inch. It will be understood that Figs. 1573 to 1576 represent only a very few of the patterns in general use and ready (or nearly so) for delivery.

PRICES OF GUN METAL STEAM VALVES.

| Diameter of valve .. inches | ¾ | ½ | ¾ | 1 | 1½ | 2 | 2½ | 3 |
|---|---|---|---|---|---|---|---|---|
| Price of Fig. 1573 .. .. | 3/4 | 4/2 | 5/4 | 7/3 | 13/9 | 23/- | 39/6 | 45/6 |
| ,, ,, 1574 .. .. | 5/- | 6/5 | 9/2 | 11/2 | 21/9 | 34/- | 51/- | 70/- |
| ,, ,, 1575 .. .. | .. | .. | .. | .. | 26/6 | 45/- | 60/- | 82/- |

PRICES OF GUN METAL CHECK VALVES.

| Diameter .. .. .. .. inches | ½ | ¾ | 1 | 1¼ | 1½ | 2 |
|---|---|---|---|---|---|---|
| Price square box, Fig. 1576, screwed ends .. | 4/9 | 6/2 | 8/3 | 11/6 | 13/6 | 20/- |
| ,, round ,, ,, flanged ,, .. | 5/3 | 8/6 | 12/- | 17/- | 21/- | 34/- |
| ,, double check screwed ends .. .. | .. | 25/- | 31/6 | .. | .. | .. |
| ,, treble ,, ,, ,, .. .. | 22/- | 26/6 | 35/- | 47/- | 63/- | .. |
| ,, gun metal balls .. .. .. .. | .. | 1/3 | 1/6 | 2/3 | 2/6 | 6/- |

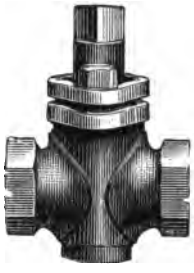


Fig. 1577.

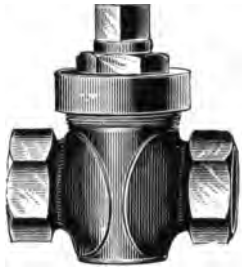


Fig. 1578.

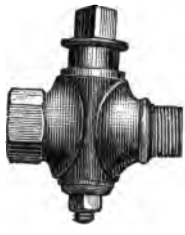


Fig. 1579.

**GUN METAL STEAM COCKS** to take square key or spanner and tested by hydraulic pressure to 200 lbs. per square inch. The cocks with screwed ends are chased to the standard gas tube thread, unless otherwise ordered and those with flanged ends, have flanges of standard dimensions. If the bodies are to be polished, add about 9d. to 2/3 each to the subjoined prices.

PRICES OF GUN METAL STEAM COCKS.

| Diameter .. .. .. .. inches | ¼ | ⅜ | ½ | ¾ | 1 | 1½ | 2 |
|---|---|---|---|---|---|---|---|
| Price Fig. 1577 screwed ends .. .. | 2/6 | 2/4 | 4/7 | 6/2 | 9/4 | 17/5 | 26/8 |
| ,, ,, flanged ,, .. .. | .. | .. | 6/7 | 8/1 | 13/- | 28/9 | 43/6 |
| ,, Fig. 1578 screwed ,, .. .. | 2/6 | 3/- | 5/4 | 8/5 | 13/- | 26/- | 39/9 |
| ,, ,, flanged ,, .. .. | .. | .. | .. | .. | 22/- | 38/3 | 59/6 |
| ,, Fig. 1579 screwed ,, .. .. | 2/4 | 3/- | 3/10 | 5/4 | 8/3 | 18/9 | 28/8 |
| ,, ,, flanged ,, .. .. | .. | 4/9 | 6/7 | 9/6 | 13/9 | 22/6 | 31/- |

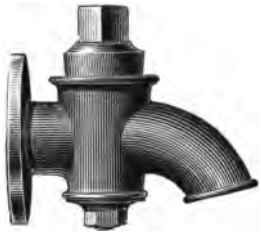


Fig. 1580.

Fig. 1581.

Fig. 1582.

**GUN METAL BLOW-OFF COCKS,** tested to a pressure of 200 lbs. per square inch.

PRICES OF BLOW-OFF COCKS.

| Diameter .. .. .. .. inches | ¾ | 1 | 1½ | 2 | 2½ |
|---|---|---|---|---|---|
| Price of Fig. 1580 screwed ends .. .. | 7/6 | 9/10 | 14/9 | 24/2 | 49/- |
| ,, ,, flanged ,, .. .. | 8/2 | 10/8 | 16/- | 26/2 | 52/10 |
| ,, Fig. 1582 ,, ,, .. .. | .. | .. | 34/- | 44/- | 59/6 |

PRICES OF GUN METAL STEAM UNIONS.

| Diameter .. .. inches | ¼ | ⅜ | ½ | ¾ | 1 | 1½ | 2 | 2½ |
|---|---|---|---|---|---|---|---|---|
| Price of Fig. 1581 .. .. | -/11 | 1/2 | 2/- | 2/9 | 3/7 | 7/4 | 9/10 | 14/1 |

**CAST IRON STEAM VALVES.**—The bodies are of a close grained cast iron, the facing pieces on the flanges are turned and the bolt holes cast in for the A finish, which are principally used in connection with boiler mountings.

The B finish, for engine fittings, have blank flanges faced across and turned on the edges; the covers, glands and hand wheels are bright. In all cases the valves, seatings, spindles and nuts are of gun metal and all parts are carefully fitted and finished.

The prices of valves with inlet and outlet at an angle, do not differ materially from the usual type indicated in Fig. 1575.

PRICES OF CAST IRON STEAM VALVES.

| Diameter .. inches | 2 | 2½ | 3 | 3½ | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| ,, of flange ,, | 6½ | 7 | 7½ | 8 | 9 | 10 | 12 | 13 | 14 |
| Thickness ,, ,, | ¾ | ¾ | 13/16 | ⅞ | ⅞ | ⅞ | 1 | 1 1/16 | 1⅛ |
| Price each A finish .. | 27/- | 29/6 | 35/6 | 46/6 | 59/6 | 82/- | 108/- | 133/- | 178/- |
| ,, ,, B ,, .. | 35/- | 38/8 | 45/9 | 58/8 | 73/3 | 99/6 | 129/- | 173/- | 208/- |

PRICES OF CAST IRON FLANGED COCKS.

| Diameter .. .. .. .. inches | 1½ | 2 | 2½ | 3 | 4 |
|---|---|---|---|---|---|
| Price of plug cock all cast iron .. .. | 9/- | 11/6 | 16/- | 21/- | 36/6 |
| ,, ,, gun metal plug .. | 13/- | 20/- | 28/- | 42/- | 75/- |
| ,, gland cock all cast iron .. .. | 14/9 | 19/6 | 24/- | 29/6 | 54/9 |
| ,, ,, gun metal plug .. | 20/9 | 26/- | 37/- | 45/- | 77/- |
| ,, plug bib cock all cast iron .. | 8/3 | 10/6 | 14/6 | 18/6 | 32/- |
| ,, ,, ,, gun metal plug .. | 12/4 | 17/6 | 24/6 | 39/- | 74/- |
| ,, gland ,, all cast iron .. | 14/6 | 17/6 | 22/- | 30/- | 52/- |
| ,, ,, ,, gun metal plug .. | 19/7 | 24/- | 35/6 | 47/- | 81/- |
| ,, ,, wheel valve cast iron .. | 18/9 | 27/- | 29/6 | 35/6 | 60/- |

PRICES OF GUN METAL EQUILIBRIUM VALVES.

| Diameter .. .. .. .. inches | ¾ | 1 | 1½ | 2 |
|---|---|---|---|---|
| Price with screwed ends .. .. .. | 9/3 | 11/6 | 21/6 | 29/- |

PRICES OF GUN METAL THROTTLE VALVES.

| Diameter .. .. .. .. inches | 1 | 1½ | 2 | 2½ |
|---|---|---|---|---|
| Price with screwed ends .. .. .. | 10/- | 1 /- | 16/- | 24/- |

**CAST IRON THROTTLE VALVE.**—The bodies are made of cast iron and the flanges are of the standard dimensions; the spindle and valve are in gun metal.

PRICES OF CAST IRON FLANGED THROTTLE VALVES.

| Diameter .. .. inches | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 |
|---|---|---|---|---|---|---|---|---|
| Price of valve .. .. .. | 15/- | 20/- | 23/6 | 27/6 | 30/6 | 34/- | 40/- | 45/- |

Fig. 1583.

Fig. 1584.

Fig. 1585.

**SIGHT FEED LUBRICATORS.**—Fig. 1583 to 1585 are useful examples of the numerous arrangements of these instruments.

**The lubricator** Fig. 1583 is entirely self-contained and merely requires to be screwed into the steam pipe or valve chest, in the same way as an ordinary grease cup.

**The lubricator** Fig. 1584 is for a double cylinder engine and in both types, the sight glass is easily removed if broken, without disconnecting the lubricator. It should be fixed on the steam pipe where possible, or on the steam chest cover, but never on the cylinder.

PRICES OF SIGHT FEED ENGINE LUBRICATORS, Figs. 1583 and 1584.

| Capacity .. .. .. .. pints | ½ | 1 | 1½ | 2 |
|---|---|---|---|---|
| Price of lubricator, Fig. 1583 .. .. | £4 6 0 | £5 5 0 | £6 5 0 | £7 15 0 |
| ,, ,, Fig. 1584 .. .. | .. | £4 14 0 | £5 17 6 | £6 16 0 |

**Journal lubricator** Fig. 1585.—The supply of lubricant is visible and is regulated by the milled nut below the lever at the top; the flow of lubricant is instantly shut off or renewed, by depressing or raising the lever at the top, without disturbing the supply adjustment. All sizes are screwed the same thread as gas tube ½-inch diameter.

PRICES OF JOURNAL LUBRICATORS, Fig. 1585.

| Capacity .. .. .. .. .. ounces | 2 | 3 | 4 |
|---|---|---|---|
| Price of lubricator .. .. .. .. .. | 7/6 | 10/- | 12/6 |

**Sight feed lubricators for air compressors,** compressed air engines, refrigerators, &c. (not illustrated).

| Diameter .. .. .. inches | 2 | 2½ | 3 | 3½ | 4 |
|---|---|---|---|---|---|
| Price of lubricator .. .. | 14/- | 20/- | 25/- | 30/- | 36/- |

Fig. 1586.

Fig, 1587.

**CRANK PIN LUBRICATORS,** Figs. 1586 and 1587 (Thayer—Reids system) for automatically supplying a defined quantity of lubricant to crank pins, cross heads, eccentrics, &c.

The regular opening and closing of the feed valve, due to the motion of the oscillating lever shown in the engraving, gives a constant and defined supply of oil, which can be accurately adjusted and not interfered with, when the receiver has to be replenished.

Fig. 1586 is the type in general use and Fig. 1587 is specially adapted for high speed engines. The economy in the consumption of oil is demonstrated by the fact, that one ounce of oil in this instrument has efficiently lubricated a locomotive coupling rod bearing, during the running of 3,800 miles.

PRICE OF LUBRICATORS, Fig. 1586.

| | | | | |
|---|---|---|---|---|
| Capacity ..ounces | 2 | 3 | 4 | 5 |
| Price of lubricator .. | 10/- | 12/6 | 15/- | 17/6 |

**The lubricator** Fig. 1587 is usually made to contain 2 ounces of oil and the price each, is £0 12 6.

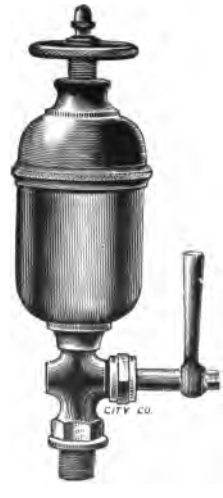


Fig. 1588.

Fig. 1589.

Fig. 1590.

Fig. 1591.

PRICES OF SUET LUBRICATORS, Fig. 1588.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Diameter of cup .. .. inches | 2 | 2½ | 3 | 3½ | 4½ | 5 | 6 |
| For nominal horse power .. .. | 5 | 7 | 10 | 20 | 30 | 50 | 70 |
| Price of lubricator .. .. .. | 16/3 | 23/- | 36/- | 45/- | 55/- | 75/- | 120/- |

**The Impermeator** Fig. 1589 combines the advantages of a displacement lubricator and an ordinary grease cup, regulated by one handle and the prices of some of the sizes usually made are as follows, smaller and intermediate sizes are made at prices corresponding with size.

PRICES OF IMPERMEATORS, Fig. 1589.

| | | | | | | |
|---|---|---|---|---|---|---|
| Capacity .. .. .. .. pints | ½ | 1 | 2 | 3 | 5 |
| For nominal horse power .. .. .. | 10 | 40 | 80 | 150 | 500 |
| Price of impermeator .. .. .. | 20/6 | 27/9 | 45/- | 70/- | 95/- |

PRICES OF DOUBLE VALVE LUBRICATOR, Fig. 1590.

| | | | | | | |
|---|---|---|---|---|---|---|
| Diameter of receiver .. .. inches | 2 | 3 | 4 | 4½ | 5 |
| Height of ,, .. .. ,, | 3 | 4 | 5 | 5½ | 6¼ |
| Price of lubricator .. .. .. | 24/- | 29/- | 38/- | 46/6 | 62/- |

PRICES OF SUET LUBRICATORS, Fig. 1591.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Diam. of receiver ins. | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 | 5 | 6 |
| Price of lubricator .. | 4/10 | 8/6 | 11/6 | 15/- | 20/6 | 25/- | 30/- | 40/- | 50/- |

Fig. 1592.

Fig. 1593.

Fig. 1594.

Fig. 1595.

**NEEDLE LUBRICATORS.**—Fig. 1592 is the well known marine type and Fig. 1593 is the crank pattern. The oil receivers are of flint glass, the mountings are in gun metal and leather only is used for making the joints. New receivers can be sent for connecting to existing fittings for renewals, provided proper dimensions are given.

PRICES OF NEEDLE LUBRICATORS MARINE PATTERN, Fig. 1592.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capacity of cylinder .. .. ounces | ⅛ | ¼ | 1 | 2 | 5 | 8 | 20 |
| Diameter ,, .. .. inches | ½ | 1 | 1½ | 2 | 2½ | 3 | 4 |
| Stem screwed for .. .. ,, | 5/16 | 3/8 | ½ | ⅝ | ⅝ | ¾ | ¾ |
| Price of lubricator .. .. .. | 2/11 | 3/3 | 4/6 | 6/- | 8/3 | 11/3 | 15/- |

**Needle lubricators** Fig. 1594 with flint or green glass receivers and wood stoppers, price per dozen 4/6.

PRICES OF NEEDLE LUBRICATORS CRANK PATTERN, Fig. 1593.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Diameter of globe .. inches | 1 | 1½ | 2 | 2½ | 3 | 3½ |
| Stem screwed for .. ,, | ⅛ | ⅛ | ¼ | ¼ | ⅜ | ⅜ |
| Price of lubricators .. .. | 2/5 | 2/6 | 2/9 | 3/2 | 3/9 | 4/6 |

PRICES OF SCREW CUPS FOR SOLID LUBRICANT, Fig. 1595.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Diameter of cup .. .. .. inches | ⅝ | ⅝ | 1½ | 2 | 2¾ | 3¼ | 4 |
| Price of cups .. .. per doz. | 8/6 | 11/6 | 18/6 | 27/- | 45/3 | 63/6 | 88/- |

**CENTRIFUGAL OIL PUMP** for continuous lubrication of main shaft bearing.
Small size price £1 5 0.
Large ,, ,, £2 5 0.

PRICES OF GUN METAL EXPANSION JOINTS WITH SCREWED ENDS.

| | | | | | | |
|---|---|---|---|---|---|---|
| Internal diameter of pipes .. .. inches | ½ | ¾ | 1 | 1¼ | 1½ | 2 |
| Price of joints .. .. .. .. .. | 4/- | 6/4 | 13/- | 16/3 | 19/- | 24/- |

PRICES OF CAST IRON EXPANSION JOINTS WITH FLANGES & GUN METAL GLANDS.

| | | | |
|---|---|---|---|
| Internal diameter of pipe .. .. inches | 2 | 3 | 4 |
| Price of joint .. .. .. .. .. | 30/- | 40/- | 51/- |

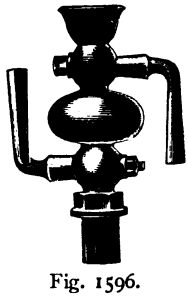


Fig. 1596.


Fig. 1597.

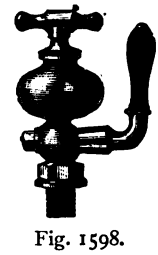


Fig. 1598.

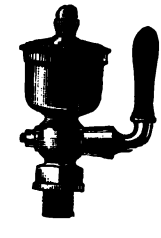


Fig. 1599.

**GREASE CUPS** Fig. 1596 to 1599 are made of gun metal and fitted with ebony or brass handles. The stems are screwed to gas thread of the sizes mentioned and intermediate sizes are made at corresponding prices.

PRICES OF GREASE CUPS, Figs. 1596 to 1599.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Internal diameter of tube .. inches | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 |
| Price of cup Fig. 1596 .. .. .. | 3/9 | 4/6 | 5/9 | 8/10 | 12/4 | 16/2 | 19/6 |
| ,, ,, Fig. 1597 .. .. .. | .. | 5/4 | 6/7 | 10/5 | 16/6 | .. | .. |
| ,, ,, Fig. 1598 .. .. .. | 2/8 | 3/7 | 5/6 | 7/6 | 9/10 | .. | .. |
| ,, ,, Fig. 1599 .. .. .. | 2/8 | 5/1 | 8/6 | 11/3 | 15/- | .. | .. |

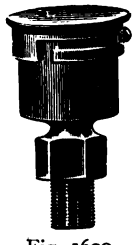


Fig. 1600.


Fig. 1601.


Fig. 1602.


Fig. 1603.

**OIL SYPHONS** of the type Fig. 1600 are made with slide or with bayonet joint lid. Fig. 1601 is open top. Fig. 1602 has a screw cover and Fig. 1603 has a spring top.

PRICES OF OIL SYPHONS, Fig. 1600 to 1603.

| Diameter .. .. inches | ¾ | 1 | 1¼ | 1½ | 1¾ | 2 | 2½ | 3 |
|---|---|---|---|---|---|---|---|---|
| Price of Fig. 1600 per doz. | 11/6 | 13/1 | 14/7 | 21/7 | 28/6 | 36/7 | 63/3 | 92/6 |
| ,, Fig. 1601 ,, | 5/9 | 7/4 | 10/5 | 12/4 | 14/3 | 15/10 | 26/2 | 46/3 |
| ,, Fig. 1602 ,, | 11/6 | 13/1 | 14/7 | 21/7 | 28/6 | 37/- | 55/6 | .. |
| ,, Fig. 1603 ,, | .. | 14/9 | 20/- | 29/6 | 37/- | 46/6 | .. | .. |

PRICES OF BELL METAL SIGNAL GONGS WITH IRON FRAMES.

| Diameter of gong .. .. .. .. .. .. | 6 | 8 |
|---|---|---|
| Price of ,, .. .. .. .. .. .. | 12/6 | 17/6 |


Fig. 1604.

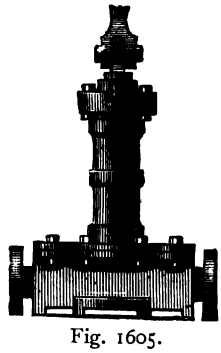


Fig. 1605.

**FEED OR FORCE PUMP** Fig. 1605.—The body is in cast iron and is fitted with hard gun metal valves and seatings and is completed with jointed rod end for welding or connecting to the rod, from the eccentric or crank.

PRICES OF PUMPS, Fig. 1605.

| Diameter .. .. inches | 1½ | 1½ | 2 | 2½ | 3 | 3½ | 4 |
|---|---|---|---|---|---|---|---|
| Price of pump .. .. .. | £2 | £2 10 | £3 10 | £4 10 | £6 | £7 10 | £9 |

**GUN METAL FOOT VALVE AND STRAINERS,** as Fig. 1604 for injector and pump suction pipes. The strainers are globular and have perforations in excess of the area of the suction pipe and the stem is screwed for wrought iron tube of the undernamed dimensions :—

PRICES OF GUN METAL FOOT VALVES AND STRAINERS, Fig. 1604.

| | | | | | | |
|---|---|---|---|---|---|---|
| Diameter of pipe .. .. .. inches | 1 | 1¼ | 1½ | 2 | 2½ |
| ,, strainer .. .. ,, | 2 | 2½ | 3 | 3½ | 4 |
| Price of foot valve .. .. .. .. | 3/6 | 5/3 | 7/- | 11/- | 18/- |
| ,, strainer .. .. .. .. | 2/9 | 4/- | 4/6 | 6/6 | 10/6 |
| ,, complete .. .. .. .. | 6/3 | 9/3 | 11/6 | 17/6 | 28/6 |

**GUN METAL SLUICE VALVES** wedge system for steam or water, the ends screwed for iron tube.

PRICES OF GUN METAL SLUICE VALVES.

| | | | |
|---|---|---|---|
| Internal diameter .. .. .. .. .. | 1 | 1½ | 2 |
| Price of valve .. .. .. .. .. | 19/- | 27/6 | 33/- |

Fig. 1607.

**SLUICE VALVES**, Fig. 1607.—These valves are suitable for steam, water, gas, air, sewage, &c., and are constructed of the best materials. The valve cases are made in cast iron in one piece, and fitted with gun metal screws and nuts, four gun metal faces, two on the body and two on the valve, and are tested by hydraulic pressure to 600 feet head of water or about 18½ kilogrammes per square centimetre. The outlets can be made with both ends flanged, or with flange and spigot or socket ends, or with spigot and socket or double socket ends, as may be required. All valves are supplied with cast iron sockets upon the spindle ends, and if desired, may be fitted with hand wheels, the additional cost of which will be found in the subjoined table. If the valves are required with faced flanges, the extra cost is given. In the smaller sizes the flanges are faced all over, but in the larger sizes they are only faced from the bore to the inner edge of the bolt holes. Bolt holes may be cast in the flanges or drilled to templates. In cases where the valves are intended to be used with existing pipes, it is always advisable to send a template of the flanges, showing the number and diameter of bolt holes. If these are not furnished or sketches with figured dimensions, the flanges will be made to the standard dimensions. These valves are sometimes made with the faces parallel and with plain spindles and handles for blast furnace work.

PRICES OF SLUICE VALVES, Fig. 1607.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter .. .. inches | 2 | 2½ | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 |
| Price with flanged or socket ends .. .. .. | 30/- | 36/- | 45/- | 54/- | 75/- | 89/- | 113/- | 150/- | 167/- | 232/- | 285/- |
| ,, with loose flanged socket and spigot ends, extra | 5/6 | 6/9 | 7/9 | 11/- | 15/- | 18/- | 25/- | 27/- | 33/- | 42/- | 72/- |
| Hand wheel, extra .. .. | 2/3 | 2/6 | 3/- | 3/3 | 3/6 | 4/- | 4/6 | 5/6 | 6/6 | 8/- | 10/- |
| Facing flanges ,, .. .. | 1/2 | 1/4 | 1/9 | 2/- | 2/3 | 2/7 | 2/10 | 3/2 | 3/6 | 4/- | 5/3 |

**LARGE SURFACE BOXES** each £0 10 6.

**WROUGHT IRON KEYS FOR SLUICE VALVES.**—Black 15/-, bright 20/- each.

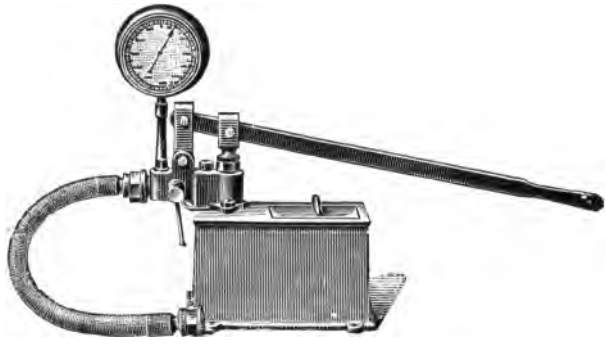


Fig. 1606.

**TEST PUMP** Fig. 1606, for testing boilers, cylinders, pipes, &c. The cast or wrought iron tank forms the base and contains the pump, suction pipe and all accessories as shown. The pump equal to a working pressure of 300 lbs. per square inch, is of gun metal and is complete with stop valve, hydraulic pressure gauge, flexible hose with union for connecting to the delivery pipe, hand lever and fulcrum link. The pressure gauge registers to 300 lbs. per square inch or the equivalent in kilogrammes (9) per square centimetre.

The ram is 1 inch diameter and the price of the pump complete as above described is £7 10.

**HYDRAULIC TUBES** of best wrought iron or mild steel are made in long lengths, plain at the end unless otherwise ordered and of various thicknesses from $\frac{3}{8}$-inch external by $\frac{1}{4}$-inch internal diameter, to 3 inches external by 2 inches internal diameter, so that if the working pressures given in the subjoined list of the tubes most in demand, are not suitable for the pipes required, it is merely necessary to state the internal and external diameter of the pipes desired, or the internal diameter and the pressure they must carry. The working pressures in the tables are about one fourth the ultimate bursting pressures.

**CONNECTIONS AND FITTINGS.**—The tubes can be supplied screwed at the ends for flanged joints, or fitted with wrought iron round or hexagon shaped sockets, or they can be screwed right and left hand, coned and faced and fitted with sockets as last named. Flanges, elbows, bends, T pieces, &c. are supplied as required.

**The standard screwing sizes** are: $\frac{11}{16}$, $\frac{13}{16}$, $\frac{7}{8}$, $\frac{15}{16}$, $1\frac{1}{16}$, $1\frac{3}{16}$, $1\frac{5}{16}$, $1\frac{1}{2}$, $1\frac{11}{16}$, $1\frac{3}{4}$, $1\frac{7}{8}$, 2, $2\frac{1}{8}$, $2\frac{3}{8}$, $2\frac{5}{8}$, 3 inch.

PRICES AND WORKING PRESSURES OF HYDRAULIC TUBES.

| Internal diameter .. .. .. inches | 1 | $1\frac{1}{4}$ | $1\frac{1}{2}$ | $1\frac{3}{4}$ | 2 |
|---|---|---|---|---|---|
| Pressure for $\frac{1}{4}$-inch thick .. .. lbs. | 4,500 | 3,500 | 3,000 | 2,500 | 2,200 |
| Price .. .. .. .. per foot | 1/2 | 1/5 | 1/8 | 1/11 | 2/2 |
| Pressure for $\frac{9}{32}$-inch thick .. .. lbs. | 5,000 | 4,000 | 3,500 | 3,000 | 2,500 |
| Price .. .. .. .. per foot | 1/5 | 1/8 | 1/11 | 2/2 | 2/6 |
| Pressure for $\frac{5}{16}$-inch thick .. .. lbs. | 5,500 | 4,500 | 3,700 | 3,200 | 2,800 |
| Price .. .. .. .. per foot | 1/7 | 1/10 | 2/2 | 2/5 | 2/9 |
| Pressure for $\frac{3}{8}$-inch thick .. .. lbs. | 6,700 | 5,400 | 4,500 | 3,800 | 3,400 |
| Price .. .. .. .. per foot | 1/11 | 2/4 | 2/8 | 3/- | 3/4 |
| Pressure for $\frac{7}{16}$-inch thick .. .. lbs. | 7,800 | 6,300 | 5,200 | 4,500 | 4,000 |
| Price .. .. .. .. per foot | 2/5 | 2/9 | 3/2 | 3/7 | 4/- |
| Pressure for $\frac{1}{2}$-inch thick .. .. lbs. | .. | 7,000 | 6,000 | 5,000 | 4,500 |
| Price .. .. .. .. per foot | .. | 3/4 | 3/9 | 4/3 | 4/8 |

**LAP WELDED IRON OR STEEL BOILER TUBES** are made of best best iron or mild steel and in various thicknesses but will be sent the *usual* gauge, which is that first specified in the list, unless ordered to be of other thickness. Lengths exceeding 18 feet are

subject to 2½ per cent. less discount, for each foot or part of a foot. One end of each tube will be swelled or reduced one sixteenth of an inch, if desired, for a length of 3 inches. An extra charge is made if swelling or reduction in diameter exceeds these limits. All diameters up to 2 inches are made any thickness up to ¼-inch and from 2 to 12 inches diameter up to ½-inch thick.

PRICES OF IRON OR STEEL BOILER TUBES.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| External diam. .. inch | 1½ | 1¾ | 2 | 2¼ | 2½ | 2¾ | 3 | 3½ | 4 | 5 |
| Thickness Imperial W.G. | 13 | 13 | 12 | 12 | 11 | 11 | 11 | 10 | 9 | 8 |
| ,, .. .. inch | 092 | ·092 | ·104 | ·104 | ·116 | ·116 | ·116 | ·128 | ·144 | ·160 |
| Price usual gauge .. per ft. | -/9½ | -/10 | -/11¾ | 1/0½ | 1/2½ | 1/3¾ | 1/5 | 1/10 | 2/4½ | 3/7 |
| ,, 1 extra ,, .. ,, | -/10½ | -/11 | 1/1 | 1/1¾ | 1/4 | 1/5¼ | 1/7 | 2/0½ | 2/7½ | 3/11 |
| ,, 2 ,, ,, .. ,, | -/11¾ | 1/0¼ | 1/2¼ | 1/3¼ | 1/5¾ | 1/7½ | 1/9 | 2/3 | 2/10½ | 4/3 |
| ,, 3 ,, ,, .. ,, | 1/0¾ | 1/1½ | 1/4 | 1/5 | 1/7½ | 1/9½ | 1/11 | 2/5½ | 3/1 | 4/8 |

**SEAMLESS COPPER TUBE.**—The following table gives the approximate weight per foot, of the standard diameters and sections, usually ready for delivery in lengths not exceeding 15 feet, but other diameters, sections and lengths, are made at short notice.

**The weight per foot** is approximately correct but cannot be guaranteed.

**The thickness of metal** in Nos. of Imperial wire gauge, is also given in decimals of an inch and, approximately, in millimetres for facility in calculating safe working pressures, these may however vary slightly.

**Prices** constantly vary but may probably range from 10 to 12 pence per lb.

WEIGHTS OF SEAMLESS COPPER TUBE.

| | | | | | | |
|---|---|---|---|---|---|---|
| Thickness Imperial wire gauge .. .. | | 8 | 10 | 12 | 14 | 16 |
| ,, .. .. .. .. inch | | ·160 | ·128 | ·104 | ·080 | ·060 |
| ,, .. .. .. .. m/m. | | 4·06 | 3·25 | 2·65 | 2·03 | 1·53 |
| Internal diam., ¼ inch .. | lbs. per foot | .. | .. | .. | .. | ·24 |
| ,, ⅜ | ,, | .. | .. | .. | .. | ·34 |
| ,, ½ | ,, | .. | .. | .. | .. | ·44 |
| ,, ⅝ | ,, | .. | .. | .. | ·68 | .. |
| ,, ¾ | ,, | .. | 1·36 | 1·07 | ·80 | .. |
| ,, 1 | ,, | .. | 1·75 | 1·39 | 1·04 | .. |
| ,, 1¼ | ,, | .. | 2·13 | 1·70 | 1·29 | .. |
| ,, 1½ | ,, | .. | 2·52 | 2·02 | 1·53 | .. |
| ,, 2 | ,, | 4·18 | 3·29 | 2·65 | 2·01 | .. |
| ,, 2¼ | ,, | 4·66 | 3·68 | 2·96 | 2·25 | .. |
| ,, 2½ | ,, | 5·15 | 4·07 | 3·28 | 2·50 | .. |
| ,, 3 | ,, | 6·12 | 4·84 | 3·90 | 2·98 | .. |
| ,, 3½ | ,, | 7·08 | 5·62 | 4·53 | 3·46 | .. |
| ,, 4 | ,, | 8·05 | 6·39 | 5·16 | 3·95 | .. |

**Wrought iron and steel steam and water tubes.**—Prices and particulars of these and their connections are given on pages 93 to 95.

**Cast iron and rivetted steel water supply pipes** are described and dimensions with approximate prices given on pages 91 to 93.

# DYNAMOS AND ELECTRIC MOTORS.

The discovery by Faraday of the induced electrical current, and the close relationship of electricity and magnetism, was the starting point of the dynamo, and the evolutions and developments of this most valuable discovery are due to the labours of Siemens, Gramme, Edison, Hopkinson and others.

Although properly speaking the dynamo is not a prime mover, but rather an intermediary for the transmission and distribution of power, yet the Writer is of opinion that reference to it and to its converse—the electric motor—may not inappropriately be made in this section.

**Generators and Motors.**—The engraving, Fig. 1614, illustrates a generator or dynamo of 100 effective horse power, but it may be regarded as representing with sufficient accuracy, other sizes of machines commonly employed for electric lighting and for transmitting power for industrial purposes.

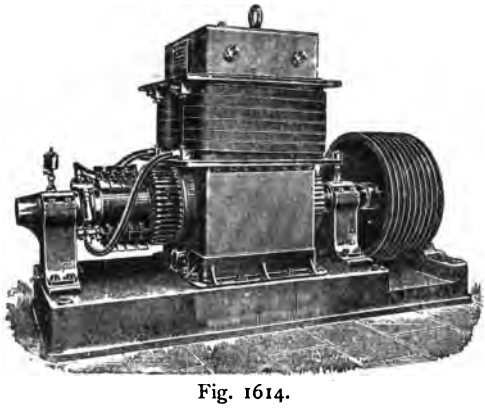


Fig. 1614.

**The advantages** of flexibility, ease in application and general convenience, are often disregarded, although these are almost invariably greater in the case of electrical transmission, than in that by any other method. As regards efficiency of transmission, the most serious rivals of the electric method are wire rope and compressed air transmission, which are referred to at p. 52 of Section VI. and in Section II. Of these, wire rope is undoubtedly the more economical for short distances, but for considerable distances it is more wasteful, long distances increasing the capital cost to an enormous extent, as compared with electrical transmission, especially for overground work. It must always be remembered, that in an uneconomical system of transmission, besides the loss of power, the prime mover—steam engine or turbine—has to be larger to supply this loss.

An efficiency of 90% being attainable in dynamos and motors of even moderate power, it follows that, under favourable circumstances and where the installation is suitably designed, as much as 80% of the brake horse power of a prime mover, may be made available at any given point within a moderate distance and 60% may be regarded as a minimum efficiency, even for great distances. It will be at once apparent that electrical transmission of power is most valuable in many cases, which will readily present themselves to the mind.

The applications of electricity to power transmission may, for the most part, be classed under two heads.—(1) Transmission from a place where steam or water power is cheap or easily obtainable, to another where it would be expensive or difficult of employment; and (2) Distribution from a central generator or generators, to a number of motors at a comparatively short distance from the generator.

Under the first head come the numerous cases where power obtained from a waterfall, is transmitted to a mill or factory at a distance, or from the surface of a colliery, where steam power is cheap, to pumps or hauling engines in the workings to which it would be difficult, wasteful or dangerous, to convey power by steam, compressed air, etc.

In cases where power is to be transmitted for driving one machine only, and the generator is not required to give power for lighting purposes also, or to drive other motors, the generator and motor are usually identical machines, and are series wound. Any spare parts are thus available for either machine, and the speed of the motor is constant and independent of the load on it; the motor also has great power of starting against a load.

Where the generator has to drive more than one motor, or give current for lighting and power at the same time, it is usually compound wound for pressures up to about 500 volts, and above this it is more convenient to excite the magnets by a separate small dynamo, which is preferably placed on the same shaft.

Either series, shunt or compound wound motors, can be run from a compound wound generator. For work where the load is steady and does not vary, such as pumps, fans, etc., series motors are preferable on account of their great starting power, but they are not suitable

for varying loads, on account of their variation in speed under these circumstances; for a varying load, shunt motors should be used to render the speed constant, within a small percentage. If it is required to have constant speed and yet start very rapidly under a heavy load, a special compound winding is used on the motors.

In "distribution" of power, electricity has mainly to compete with small independent engines (as in the case of ironworks, etc.) and with shafting and belting. In the first case the advantages of using motors are as follows:—

1. There is no steam lost by condensation.
2. There is a great saving in labour and in lubrication, and motors run without the constant attention that a steam engine requires.
3. The repairs are less, as there are only two (or three) bearings, and there is no reciprocating motion—therefore little wear.
4. The power is produced by one large and economical engine, instead of a number of small and wasteful engines.
5. In case of a sudden overload, the motor, if properly designed, does not pull up as an engine would, but keeps a steady speed, and furnishes the extra power required without injury, for a short time.

As regards the advantages of motors over shafting, the last remark also applies, and further, if one room or one tool is not in use, its motor can be stopped, and there is no waste of power such as is incurred by running shafting idle.

It may be of use to state briefly that electric pressure is measured in "volts" and the volume of current in "ampères." The product of these two quantities multiplied together, is expressed in "watts," the watt being one 746th part of a horse power. Thus, as the volts and ampères can be read at any time on the voltmeter and ammeter, the power which is being given off by a generator or taken by a motor, can be readily found in horse power, and, as the normal power required is usually known, any leakage of current is at once indicated on the ammeter.

Where distances are not great—up to say 3 or 4 miles—between the dynamos and the farthest point at which it is desired to use the current, it is advisable to employ so called continuous current machinery, that is, machinery in which the current is so produced and collected, that it flows continuously in one direction. A pressure of 100 to 200 volts is not exceeded for short distances, such as those usually requisite for distribution of power in mills, ironworks, etc., but a pressure of about 500 volts is usual for fairly long distances of transmission, up to say 1 mile.

For distances up to 15 or 20 miles, the electric pressure will range from 2000 to 3000 volts. For very great distances, alternating current plant with higher pressures is used, as this system lends itself better than the continuous system, to the generation of the current at a comparatively low pressure, and the raising of the pressure by means of a converter. An alternating current converter (or transformer) consists only of two or more coils of wire with iron cores, enclosed in an iron box, and has no moving parts, while a continuous current transformer consists of a high pressure motor, driving a low pressure generator (or vice versa), though the two are usually combined in one machine, known as a "Dynamotor."

The reason, in cases of transmission to a distance, for keeping the pressure as high as convenient, is, that the section of the cable varies directly with the volume of current and is independent of the pressure of the current; for example, if it is decided to work with a loss in the cable of one tenth of the total pressure, then, if the current be doubled, the amount of copper in the cable must also be doubled, in order that there may be the same loss of pressure. In this way, supposing a cable is employed one mile in total length ($\frac{1}{2}$-mile between dynamo and motor) and suitable for a current of 20 ampères, the loss of pressure being say 50 volts, then, if the dynamo gives 100 volts, the loss of pressure in the cable will be 50% of the total, and deducting 20% more for losses in dynamo and motor, the percentage of the brake H.P. of the engine which will be given out on the motor shaft, will be only about 30%. If however, the pressure of the dynamo is 200 volts, the loss in the cable (the size remaining the same) will be only 25%, and the total efficiency about 55% instead of 30%, or, taking a more usual pressure for such a case, if the dynamo gives 500 volts, the loss in the cable will be only 10%, and the total efficiency about 70%.

These figures are merely given as a sort of general illustration; no fixed rules can be laid down as to the best percentage loss in the cable, as many points arise that have to be taken into account:—for example, if it is proposed to work with a 10% loss in the cable, it will be necessary to consider, whether the interest on the cost of cable will be more or less than the annual cost of the power lost in it, together with that of a larger or smaller engine and generator; obviously the cheapest size of cable (disregarding other minor points) is that in which the interest on the cost, is equal to the annual value of the power lost; for with this size, if the cable is diminished, the cost is increased by power lost, and vice versa, if the size of cable is increased, the cost is increased by interest on capital. It will be plain from the foregoing that the most economical size of cable to use, is a question largely affected by the cost of power.

**COMBINED ENGINE AND DYNAMO.**—The engraving Fig. 1615, represents a steam dynamo consisting of a pair of vertical engines, specially constructed for coupling the dynamo shaft to the crank shaft of the engines, which are arranged to run at the speed requisite for giving the best useful effect.

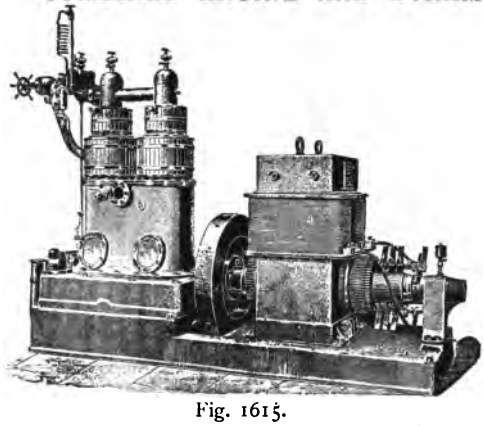


Fig. 1615.

Installations of this type possess the advantage of freedom from risk. of stoppage, caused by the breakage or slipping of driving belts or ropes, also of the absence of wear and loss of power incidental to theside pull of belts or ropes

**TURBINE DRIVEN DYNAMOS.**—It will be understood that it is quite easy to substitute a turbine driven by steam or by water (see Figs. 1627 to to 1630 and prices) for the engine shown in Fig. 1615 and that the results obtained from well arranged machinery of hi kind, must be highly satisfactory as regards efficiency and economy.

**Prices of dynamos and motors.**—Electrical installations vary so widely and need to be considered from so many points of view that—without special technical knowledge – lists of prices are of little assistance in determining questions relating to these appliances. The following prices for dynamos and motors of the types Figs. 1614 and 1615, given on pages 77 and 78, may however be useful and further information will gladly be furnished on receipt of details relating to the conditions to be fulfilled. The nature of such details is given generally, under the heading "Information required" which will be found further on.

**Driving arrangements.**—The dynamo may be combined on one bed plate with the prime mover and its shaft be coupled directly to the turbine or to the crank shaft, as shown in Fig. 1615, or it may be driven by belt or rope in the usual manner, from the turbine, steam, gas or oil engine, as shown in Figs. 1616 and 1617.

**Information required.**—The following details should be given as completely as possible, in all cases where advice is desired, with reference to the installation to be put down.

1. Number of motors to be put down and the brake horse power to be taken off each.
2. The distance from the dynamo to the motor or motors.
3. Is perfect regularity of speed essential?
4. What is the nature of the work? Is it continuous or intermittent? Will the motors usually work with the full load or not?
5. Are the motors to be subject to high temperatures, dampness, or other exceptional conditions?
6. Is the line to be overhead or underground and if the former, are poles required? What is the nature of the ground to be traversed?
7. Is the generator to be coupled direct to the prime mover or driven by belt or rope and, if so, give the speed and dimensions of the driving pulley?
8. How much power is available for driving the generator or dynamo?
9. Is motive power to be supplied? If steam, state cost of coal and whether water for condensing is available? If water power motor is to be provided, state the head available and—unless the supply is unlimited—state the quantity available as ascertained by rule at pages 86 and 87. If boiler power exists, give the pressure of steam.
10. If a dynamo is already in use, give the output and present work.
11. Give a plan as fully detailed as possible, showing the relative positions of generators and motor, with distances.

**ESTIMATES FOR POWER INSTALLATIONS.**—As already indicated, dynamos and motors are required to work under such widely differing conditions, that the cost of these installations cannot be determined, without ample information of the kind last referred to. The following approximate estimates will however convey an idea of the outlay requisite under the circumstances mentioned and—at the same time—illustrate some of the points to which attention has been directed in the preceding remarks.

**ESTIMATE No. 1 FOR INSTALLATION OF 20 HORSE POWER.**—For transmitting 20 effective horse power a distance of one mile, requires one generator and one motor. The pressure at the generator is 500 volts and, allowing for a loss in the line of 50 volts, 28 brake horse power must be provided to drive the generator.

The plant consists of one series wound dynamo No. 2, with sliding rails and tightening apparatus. One series wound motor No. 2 of 20 brake horse power, two miles of bare copper wire conductor with insulators, switch board with instruments, starting switch for motor, &c.

**The price of the installation,** exclusive of engine or driving belts, or of poles—of which about 40 will probably be required—is .. .. .. .. .. .. £500 0 0

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**ESTIMATE No. 2 FOR DISTRIBUTING POWER.**—This plant distributes power to the undernamed motors at distances not exceeding 200 yards from the generator, and comprises:—

One compound wound dynamo, No. 29, with rails and tightening apparatus, switch board with instruments, starting switches for motors, etc. The pressure at the generator is 220 volts, and the power required to drive it is 99 brake horse power.

There are three shunt or series wound motors, No. 14, each of 10 brake horse power, with rails and tightening apparatus.

Three as above, No. 12, each of 5 brake horse power.
Two ,, No. 6, ,, 2 ,, ,,
Two ,, No. 3, ,, 1 ,, ,,

and about 2½ miles of cable, of the sections suitable for the different powers of motors.

This dynamo may also be used for electric lighting and is capable of supplying 1000 incandescent lamps, each of 16 candle power.

**The price,** exclusive of engine, belts, etc., is .. .. .. .. £1110 0 0

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**THE SERIES WOUND GENERATORS AND MOTORS** referred to in the foregoing estimates and in the following tables, are respectively for 500 and 450 volts. The construction of these machines is generally indicated in Fig. 1617, and each is complete with sliding rails, tightening appliances, etc.

PRICES OF SERIES GENERATORS FOR 500 VOLTS.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Reference number .. .. | | 1 | 2 | 3 | 4 | 5 | 6 |
| Current in ampères .. .. | | 20 | 40 | 58 | 94 | 158 | 185 |
| Revolutions per minute .. | | 950 | 825 | 775 | 700 | 560 | 510 |
| Driving H.P. required .. .. | | 17 | 34 | 49 | 71 | 103 | 138 |
| Price of generator .. .. | | £145 | £176 | £290 | £422 | £535 | £600 |
| Approximate weight .. | cwts. | 20 | 25 | 59 | 90 | 111 | 120 |

PRICES OF SERIES MOTORS FOR 450 VOLTS.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Reference number .. .. | | 1 | 2 | 3 | 4 | 5 | 6 |
| Brake H.P. yielded .. .. | | 10 | 20 | 30 | 50 | 75 | 100 |
| Revolutions per minute .. | | 850 | 700 | 650 | 600 | 500 | 460 |
| Price of motor .. .. .. | | £145 | £176 | £290 | £422 | £535 | £600 |
| ,, starting switch .. .. | | £5 | £10 | £15 | £22 | £30 | £40 |
| Approximate weight .. | cwts. | 20 | 25 | 59 | 90 | 111 | 120 |

The cost of packing for shipment and delivery f.o.b. is usually about 5 per cent.

**DYNAMOS OR GENERATORS** of the types Figs. 1616 and 1617 are shunt or compound wound and are adapted for transmitting power through the relatively short distances usually required in factories, at pressures not exceeding about 200 volts. They can also be used for electric lighting and can be wound for other pressures; but if these exceed 200 volts the cost is increased.

The larger sizes referred to in the lists of prices, speeds, &c. have three bearings as shown in Fig. 1615 and, in all cases, they are fitted with automatic ring oiling bearings.

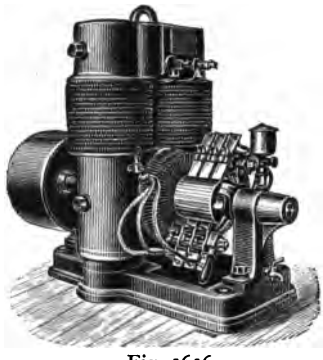


Fig. 1616.

Fig. 1617.

PRICES OF LOW PRESSURE DYNAMOS, Figs. 1616 and 1614.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Reference number .. | 1 | 2 | 3 | 5 | 6 | 8 | 9 | 11 | 12 |
| Volts at terminals .. | 65 | 65 | 65 | 115 | 65 | 115 | 65 | 105 | 65 |
| Current in ampères .. | 18 | 24 | 35 | 35 | 80 | 35 | 100 | 90 | 150 |
| Approx. revs. per min.. | 1000 | 1300 | 830 | 1500 | 1250 | 1050 | 850 | 1150 | 1100 |
| ,, H.P. at belt .. | 2 | 2½ | 3¾ | 6¾ | 8 | 7 | 10¼ | 15 | 15 |
| Maxim. 16-candle lamps | 19 | 26 | 38 | 67 | 86 | 76 | 108 | 157 | 162 |
| Price of machine .. | £33 | £33 | £44 | £44 | £66 | £66 | £80 | £80 | £80 |
| ,, tightening gear.. | £2 | £2 | £3 | £3 | £3 | £3 | £4 | £4 | £4 |
| Approx. weight .. cwts. | 3½ | 3½ | 4¾ | 4¾ | 6 | 6 | 11½ | 11½ | 9 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Reference number .. | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Volts at terminals .. | 115 | 105 | 65 | 115 | 65 | 115 | 65 | 115 | 115 |
| Current in ampères .. | 80 | 90 | 230 | 135 | 200 | 200 | 275 | 275 | 220 |
| Approx. revs. per min.. | 1000 | 1100 | 770 | 900 | 470 | 830 | 450 | 800 | 500 |
| ,, H.P. at belt .. | 14¼ | 14¾ | 23 | 24 | 22 | 38½ | 27 | 48 | 38 |
| Maxim. 16-candle lamps | 153 | 157 | 249 | 259 | 238 | 422 | 298 | 527 | 422 |
| Price of machine .. | £80 | £80 | £115 | £115 | £140 | £140 | £170 | £170 | £230 |
| ,, tightening gear.. | £4 | £4 | £4 10 | £4 10 | £5 10 | £5 10 | £6 10 | £6 10 | £7 10 |
| Approx. weight .. cwts. | 9 | 9 | 13 | 13 | 18½ | 18½ | 24½ | 24½ | 37 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Reference number .. | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| Volts at terminals .. | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 |
| Current in ampères .. | 340 | 180 | 270 | 330 | 350 | 450 | 480 | 520 | 620 |
| Approx. revs. per min.. | 750 | 900 | 900 | 900 | 750 | 750 | 750 | 650 | 650 |
| ,, H.P. at belt .. | 58½ | 31 | 46 | 56½ | 60 | 76 | 86 | 99 | 110 |
| Maxim. 16-candle lamps | 652 | 345 | 517 | 632 | 690 | 862 | 920 | 996 | 1190 |
| Price of machine .. | £230 | £150 | £190 | £210 | £230 | £270 | £290 | £330 | £390 |
| ,, tightening gear.. | £7 10 | £6 10 | £6 10 | £6 10 | £7 10 | £8 10 | £9 10 | £11 10 | £12 10 |
| Approx, weight .. cwts. | 37 | 25 | 31 | 34 | 43½ | 56 | 61 | 75¼ | 89 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Reference number .. | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| Volts at terminals .. | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 |
| Current in ampères .. | 720 | 600 | 800 | 940 | 1120 | 1400 | 1040 | 1400 | 1560 |
| Approx. revs. per min.. | 650 | 450 | 575 | 500 | 500 | 460 | 320 | 330 | 420 |
| ,, H.P. at belt .. | 114 | 114 | 142 | 161 | 193 | 222 | 180 | 230 | 263 |
| Maxim. 16-candle lamps | 1380 | 1150 | 1533 | 1802 | 2146 | 2680 | 2070 | 2680 | 3065 |
| Price of machine .. | £430 | £520 | £520 | £610 | £680 | £770 | £770 | £925 | £925 |
| ,, tightening gear.. | £12 10 | £15 | £15 | £16 | £16 | £18 | £18 | £20 | £20 |
| Approx. weight .. cwts. | 93¾ | 110¾ | 110½ | 140 | 160 | 175 | 175 | 270 | 270 |

**ELECTRIC MOTORS** illustrated by Figs. 1616 and 1617 can be wound for any pressure—those referred to in the tables are for up to 200 volts. If higher pressures are required, special quotations should be obtained. Starting switches are included in the prices of the motors.

**SMALL MOTORS.**—These are constructed as shown in Fig 1617 and being almost completely encased, are suitable for positions where little attention can be given to them. The bearings are self-adjusting and self-lubricating as in the motors previously referred to, and the sizes usually made are of ¼ to 2 brake H.P.

The effective horse power, the dimensions of parts, &c. will be found in the tables relating to motors and further information in regard to such details, or to motors of higher or other powers, will be furnished when desired.

PRICES OF LOW PRESSURE MOTORS, Fig. 1616 and 1617.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Reference number .. .. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Maximum effective H.P. .. | ¼ | ½ | 1 | 1¼ | 1⅝ | 2 | 2½ | 4 |
| Approx. revolutions per min. | 1700 | 1500 | 1200 | 930 | 1210 | 1150 | 770 | 1250 |
| Diameter of pulley .. inches | 2¾ | 3½ | 4½ | 6 | 6 | 6 | 7½ | 7½ |
| Width of ,, .. ,, | 1½ | 2 | 2¾ | 3 | 3 | 3⅜ | 3½ | 3½ |
| Price of motor .. .. .. | £14 | £21 | £26 | £33 | £33 | £38 | £49 | £49 |
| ,, tightening gear .. | .. | .. | .. | £2 | £2 | .. | £3 | £3 |
| Approximate weight .. cwts. | ½ | ¾ | 1¼ | 3½ | 3½ | 2 | 4¾ | 4¾ |
| Reference number .. .. | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Maximum effective H.P. .. | 4½ | 6 | 4½ | 6 | 7½ | 10¾ | 7½ | 10¾ |
| Approx. revolutions per min. | 980 | 1400 | 880 | 1350 | 790 | 1070 | 700 | 1050 |
| Diameter of pulley .. inches | 7½ | 7½ | 7½ | 7½ | 9 | 9 | 9 | 9 |
| Width of ,, .. ,, | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 |
| Price of motor .. .. .. | £66 | £66 | £73 | £73 | £83 | £83 | £89 | £89 |
| ,, tightening gear .. | £3 | £3 | £3 | £3 | £4 | £4 | £4 | £4 |
| Approximate weight .. cwts. | 6 | 6 | 4½ | 4½ | 11½ | 11½ | 9 | 9 |
| Reference number .. .. | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Maximum effective H.P. .. | 10¼ | 18 | 16¾ | 30 | 21 | 37 | 30 | 47 |
| Approx. revolutions per min. | 470 | 850 | 440 | 780 | 420 | 750 | 470 | 710 |
| Diameter of pulley .. inches | 11 | 11 | 12 | 12 | 13 | 13 | 15 | 15 |
| Width of ,, .. ,, | 7 | 7 | 9 | 9 | 10 | 10 | 12 | 12 |
| Price of motor .. .. .. | £124 | £124 | £154 | £154 | £188 | £188 | £252 | £252 |
| ,, tightening gear .. | £4 10 | £4 10 | £5 10 | £5 10 | £6 10 | £6 10 | £7 10 | £7 10 |
| Approximate weight .. cwts. | 13 | 13 | 18½ | 18½ | 24½ | 24½ | 37 | 37 |

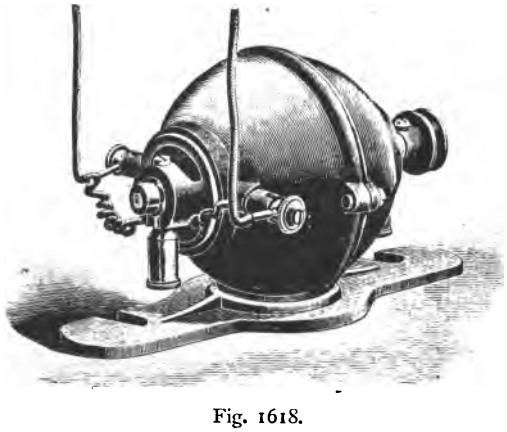


Fig. 1618.

**SMALL SLOW SPEED MOTORS.**—Fig. 1618 represents a form of motor which is largely and usefully employed in many industries.

The machine is neatly finished and is provided with self lubricating bearings.

PRICES OF SMALL MOTORS, Fig. 1618.

| | | |
|---|---|---|
| Brake horse power | 1/12 | ⅛ |
| Approx. revolutions per minute .. | 1900 | 1800 |
| Volts .. .. | 115 | 115 |
| Diam. of V grooved pulley .. inch | 1 | 1½ |
| Price of motor .. | £5 10 | £8 |

# GAS AND OIL ENGINES.

**GAS ENGINES.**—Fig. 1619 illustrates the type of engine constructed for moderate powers and working on the well known four cycle principle (an impulse at alternate revolutions). The working parts have ample surfaces, all of which are perfectly accessible, and the driver need not be (and rarely is) a skilled mechanic.

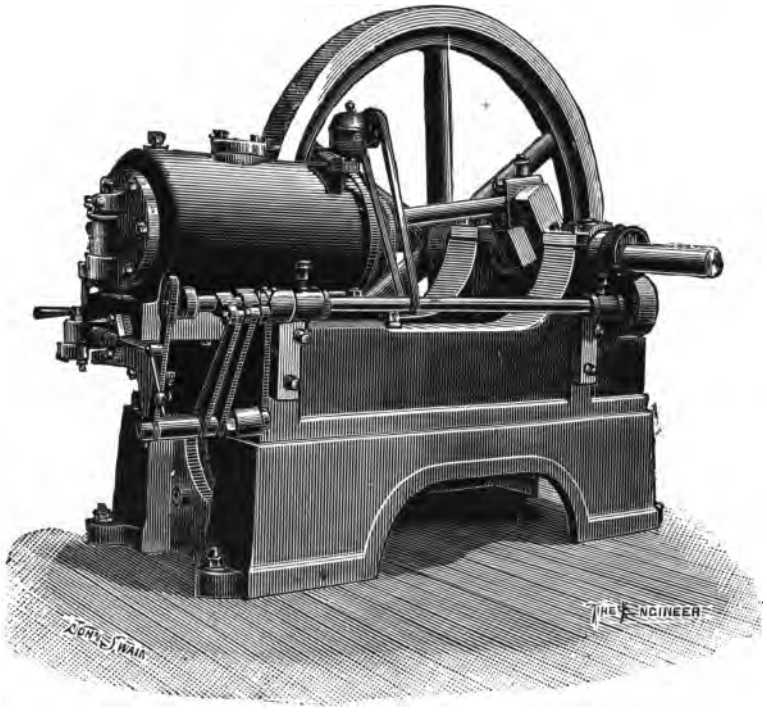



Fig. 1619.

The salient advantages (apart from their well known economy) which these engines possess are :—

The absence of exhaust steam and of dirt and dust caused by coal, ashes and smoke.

The short time, a few minutes, required to start and that they are unaffected by bad stoking.

The small quantity of water used. The low rate for insurance, if any.

The question of economy can be determined in any part of the world, if it be remembered that the consumption of gas varies, from about 16 or 18 cubic feet per indicated horse power per hour, according to the quality supplied, and that the best results obtained during the tests of steam engines at the Royal Agricultural Show in 1890, was, the consumption of 10 to 14 lbs. of best coal per indicated horse power, whilst records in respect of a large number of steam engines, working under their usual conditions, gave an average of 18 lbs. of coal.

It should be remembered that the power of the engine stated, is that actually given off, the "indicated horse power" being considerably in excess of that stated; also that this is proved by careful test before delivery.

The massive cast iron foundation carries the silence box, the feet being arranged to admit of the pipes being laid in any direction desired.

The cylinder is provided with a liner, which is easily taken out for re-boring. The shafts and spindles are of steel, all joints and other parts being hardened where that is necessary.

The crank shaft bearings are of phosphor bronze with large surfaces, and the engine is complete with all accessories shown, including a gas bag, springs, exhaust box, driving pulley, 24 spare ignition tubes, piston rings, and spanners to fit all nuts.

These engines are frequently supplied in conjunction with Dynamos, pumps, or other machinery, and designs will be prepared and estimates given for complete installations, including the engine, machines, driving shaft, bearings, pulleys, &c.

Arrangements are frequently made whereby the engine may be used for driving ordinary machinery during the day and for running a dynamo, at night, for electric lighting purposes.

The prices of engines exceeding 20 brake (about 52 indicated horse power) will be given when required, also for water vessels for the larger powers of engines.

PRICES OF GAS ENGINES, Fig. 1619.

| | | | | | | |
|---|---|---|---|---|---|---|
| Brake horse power .. .. | ½ | 1 | 2 | 3 | 4 | 6 |
| Indicated ,, .. .. | 2·7 | 4 | 5·7 | 7 | 9·5 | 12·5 |
| Price of engine .. .. .. | £48 | £59 | £68 | £78 | £92 | £106 |
| ,, water vessel .. .. | £1 10 | £2 10 | £3 5 | £3 10 | £4 | £4 10 |
| Diameter of driving pulley ins. | 10 | 12 | 12 | 18 | 18 | 21 |
| Revolutions per minute .. | 200 | 200 | 200 | 200 | 200 | 200 |
| Diameter gas supply pipe inch. | ½ | ½ | ¾ | ¾ | 1 | 1 |
| Size of meter required .. lights | 5 | 10 | 20 | 20 | 30 | 30 |
| Approximate weight .. tons | ¾ | 1 | 1¼ | 1½ | 2 | 2½ |
| | | | | | | |
| Brake horse power .. .. | 7 | 8 | 10 | 12 | 16 | 20 |
| Indicated ,, .. .. | 16 | 18·5 | 25 | 27 | 40 | 52 |
| Price of engine .. .. .. | £118 | £125 | £144 | £159 | £236 | £280 |
| Diameter of driving pulley ins. | 24 | 24 | 30 | 30 | 48 | 54 |
| Revolutions per minute .. | 185 | 180 | 180 | 180 | 170 | 160 |
| Diameter gas supply pipe ins. | 1¼ | 1½ | 2 | 2 | 2½ | 2½ |
| Size of meter required .. lights | 40 | 50 | 60 | 60 | 100 | 150 |
| Approximate weight .. tons | 3 | 3½ | 4¼ | 4¾ | 6¼ | 7½ |

The cost of packing for shipment and delivery f.o.b. is usually about 5 per cent.

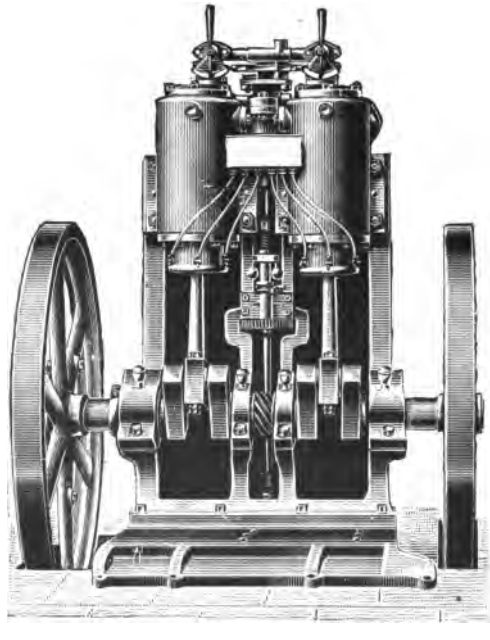


Fig. 1620.

**DOUBLE CYLINDER GAS ENGINES** of the type Fig. 1620 have been designed and made for working at high speed with great regularity, and for developing the largest possible power, in the smallest possible space. These results have been completely obtained by adopting the four cycle principle, which, with two cylinders, gives an impulse at each revolution of the crank shaft. The working parts are carefully balanced and it has been found that engines up to about 10 actual horse power, work with great regularity in speed when running at 200 to 300 revolutions per minute. They can be arranged to work with or without the silent exhaust, and they are, obviously, well adapted for driving dynamos, centrifugal pumps, screw propellers, or any machinery which demands high speed and steadiness in revolutions.

The price of an engine of this construction to develop 10 effective horse power, is £135 and estimates for engines of higher powers will be given on application, accompanied by particulars as to power, &c. required.

**VERTICAL DOUBLE AND THREE CYLINDER GAS ENGINES.**—These are so similar in design and arrangement to the oil engine Fig. 1622, that it will be unnecessary to repeat the descriptions of them.

**MOTOR GAS MAKING PLANT.**—The economy of the system now referred to is established by the fact, that the motor gas is produced with a consumption of only about 1¼ lbs. of fuel per indicated horse power per hour.

The plant is made of almost any capacity from that required to supply about 4 nominal horse power and, as will be seen from the following approximate prices for a few sizes of the apparatus, the larger the output of gas, the lower is the relative cost of plant.

The process is extremely simple and is employed with great advantage in connection with engines of large aggregate power or where ordinary gas cannot be obtained at moderate cost. The plant is sent complete with all accessories, ready for erection and setting to work.

**Fuel.**—The prices are for apparatus to work with anthracite coal but the plant is made to work with ordinary small gas coke and the extra cost of this is about £10 to £12.

PRICES OF MOTOR GAS MAKING PLANT.

| For engines of indicated H.P. .. .. | 12 | 20 | 30 | 40 |
|---|---|---|---|---|
| Price of plant .. .. .. .. | £180 | £205 | £220 | £237 |

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

**OIL ENGINES** driven by petroleum or ordinary lamp oils, or if necessary, by creosote or the heavier oils, so closely resemble the gas engine above described, that another engraving is unnecessary, and as in it, the four cycle system is adopted. The following brief description will clearly indicate the principle on which this very useful type of engine is constructed, and the subjoined data afford a basis for estimating the cost of working, closely enough for all practical purposes.

A closed tank containing the oil for supplying power, is fixed in the engine room, or in a convenient position at almost any distance from it. This tank is connected with the engine by a wrought iron pipe, and the exact quantity of oil required for each stroke is automatically forced, by a small pump driven by the engine, into the vapourizing chamber, which is fixed behind the cylinder. The oil is here converted into oil gas, by the introduction of a proper charge of atmospheric air, and the fluid thus formed is compressed before it passes into the combustion chamber, where it is brought into contact with a special form of oil lamp which is used for heating up, for starting, and afterwards, for heating the ignition tube. This simple cycle of operations continues as long as the engine is running.

Oil engines, being really engines which make their own gas from cheap oils in common use in every civilised country, possess all the advantages referred to under the head of "Gas Engine," and the relative cost of working steam, gas and oil engines, is easily ascertained by comparing the prices current in the locality where the engine is to be used, of coal and labour for driving the steam engine, of gas per 1,000 cubic feet for the gas engine, and of oil per gallon for the oil engine, allowing three quarters of a pint of petroleum oil for each "brake" or actual horse power per hour. It may be useful to state that the annual cost of working in England, has been ascertained to be as follows :—

A steam engine developing an average of 5 horse power, cost £109 2s. 0d. per annum.

An oil engine developing the same power, £51 6s. 6d. The oil generally used has a specific gravity of 0·810 and a flashing point of 150° fah., by the Abel test.

Instructions, easily understood by any person of ordinary intelligence, are sent with each engine in regard to starting, stopping, cleaning, &c., and every engine is carefully tested before it leaves the works.

PRICES OF SINGLE CYLINDER OIL ENGINES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Brake horse power .. .. | | 1½ | 2 | 4 | 6 | 9 | 12 |
| Indicated ,, .. .. | | 2 | 3 | 5 | 7½ | 10½ | 14½ |
| Price of engine .. .. .. | | £70 | £85 | £100 | £120 | £135 | £175 |
| ,, water tank .. .. | | £4 5 | £5 10 | £6 10 | £8 10 | £9 | £10 10 |
| ,, driving pulley .. .. | | 15/- | 17/- | £1 5 | £1 10 | £2 | £3 |
| Dimensions of ,, .. | inches | 10 by 5 | 12 by 6 | 18 by 7 | 18 by 8 | 21 by 9 | 24 by 12 |
| Revolutions per minute .. | | 250 | 240 | 240 | 240 | 240 | 240 |
| Approximate weight .. | tons | ¾ | 1 | 1½ | 1¾ | 2¼ | 2¾ |

The cost of packing for shipment and delivery f.o.b. is about 6 per cent.

**VERTICAL DOUBLE CYLINDER OIL ENGINES** of the type Fig. 1620 fulfil the conditions referred to in the description of these engines.

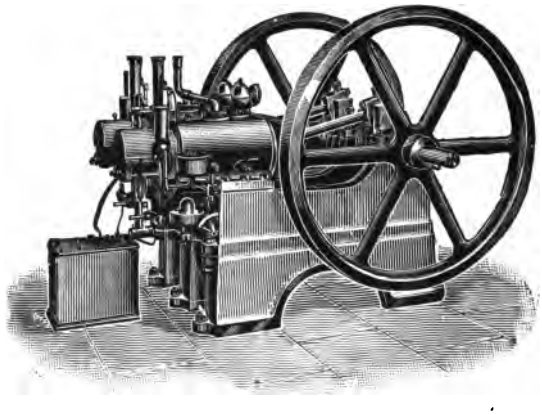


Fig. 1621.

**HORIZONTAL DOUBLE CYLINDER OIL ENGINES.**—The cylinders are side by side and the crank shaft carries two fly wheels and will take a driving pulley at either or both ends. The steadiness in speed recommends these engines for driving dynamos or any other kind of machinery where regularity in speed is essential.

PRICES OF HORIZONTAL DOUBLE CYLINDER OIL ENGINES, Fig. 1621.

| | | | |
|---|---|---|---|
| Brake horse power .. .. .. .. | 12 | 18 | 24 |
| Indicated ,, .. .. .. .. | 15 | 21 | 29 |
| Price of engine .. .. .. .. | £215 | £240 | £300 |
| ,, driving pulley .. .. .. .. | £3 | £3 2 | £3 5 |
| Diameter ,, .. .. .. inches | 24 by 12 | 27 by 12 | 30 by 12 |
| Revolutions per minute .. .. .. .. | 220 | 220 | 220 |

**VERTICAL THREE CYLINDER OIL ENGINES.**—The neat and compact arrangement shown in Fig. 1622, (also made to work with gas) occupies very small floor space in proportion with the power developed. The moving parts are carefully balanced, and the large number of cycles of operations, admit of the engine being run at wide variations in number of revolutions, with great regularity in speed in each case.

The cylinders can be worked separately or in any combination, so that the power used may be in close relation with the work done.

PRICES OF VERTICAL THREE CYLINDER OIL ENGINES, Fig. 1622.

| | | | |
|---|---|---|---|
| Brake horse power .. .. .. .. | 15 | 18 | 31 |
| Indicated ,, .. .. .. .. | 19 | 24 | 37 |
| Price of engine .. .. .. .. | £280 | £330 | £450 |
| ,, driving pulley .. .. .. .. | £3 2 | £3 5 | £3 10 |
| Dimensions of ,, .. .. .. inches | 27 by 12 | 30 by 12 | 36 by 12 |
| Revolutions per minute .. .. .. .. | 220 | 220 | 220 |

**VERTICAL DOUBLE CYLINDER OIL ENGINES**—also made to work with gas—are similar in construction to Fig. 1622, but have two, instead of three cylinders, supported on bright wrought iron columns; crank shaft is provided with two fly wheels and is long enough to take a pulley at either end.

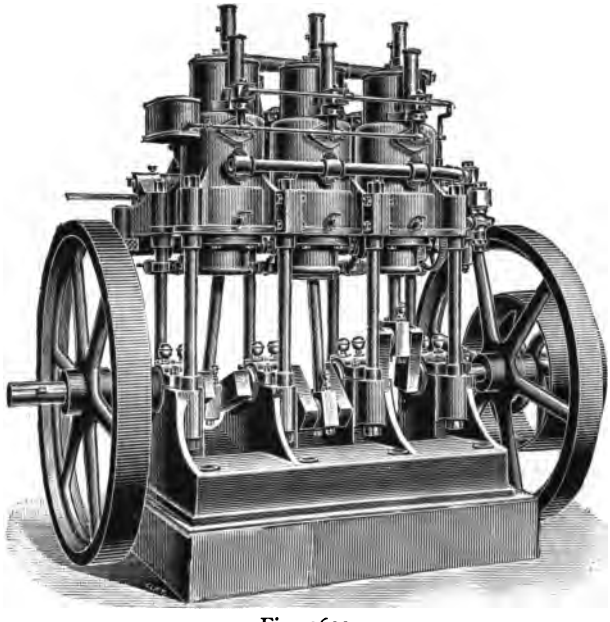


Fig. 1622

PRICES OF VERTICAL DOUBLE CYLINDER OIL ENGINES.

| | | | | |
|---|---|---|---|---|
| Brake horse power.. .. .. .. | 10 | 13 | 16 | 21 |
| Indicated ,, .. .. .. .. | 12 | 16 | 20 | 26 |
| Price of engine .. .. .. .. | £215 | £240 | £250 | £350 |
| ,, driving pulley .. .. .. | £3 | £3 2 | £3 5 | £3 10 |
| Dimensions of ,, .. .. inches | 24 by 12 | 27 by 12 | 30 by 12 | 36 by 12 |
| Revolutions per minute .. .. .. | 220 | 220 | 220 | 220 |

PRICES OF PORTABLE OIL ENGINES, Fig. 1623.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Brake horse power .. .. | 4 | 6 | 9 | 12 | 18 | 25 |
| Indicated ,, .. .. | 5 | 7½ | 10½ | 14½ | 22 | 29 |
| Price of engine .. .. | £130 | £145 | £165 | £210 | £300 | £350 |
| ,, overhead tank .. | £8 | £10 | £10 | £10 | £10 | £10 |
| Revolutions per minute .. | 220 | 220 | 220 | 220 | 220 | 220 |

**PORTABLE OIL ENGINES.**—The engraving, Fig. 1623, represents the engine with a wrought iron under carriage on wrought iron road wheels and swivelling fore carriage, and containing a tank for the cooling water; this may, however, be supplied from a cistern alongside or from any other source, in the same manner as an ordinary portable steam engine.

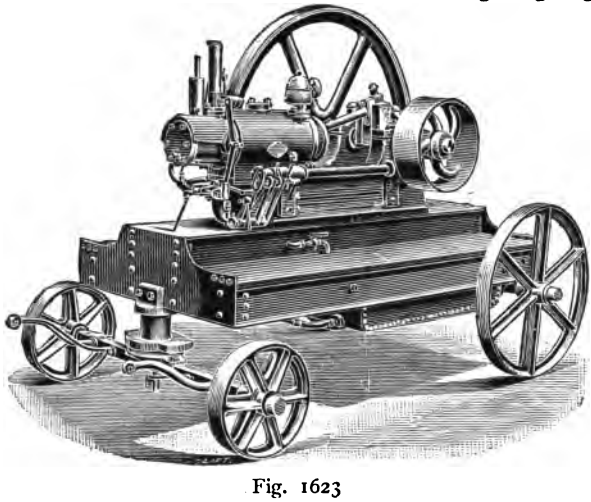


Fig. 1623

The under carriage also contains an oil tank and exhaust box, and the engine is complete with circulating pump, tool box, and driver's tools.

The circulating water tank is frequently fixed above the engine, supported on wrought iron stancheons; the extra cost of this useful attachment will be found on the preceding page.

**HOT AIR ENGINES.**—Although heated air engines of the larger powers are no longer used, small motors of the construction shown in Fig. 1624 and developing up to about two effective horse power, are still employed for pumping, driving small machines, &c. The firing is practically the same as that for an ordinary stove, and skilled labour to attend to these engines is quite unnecessary.

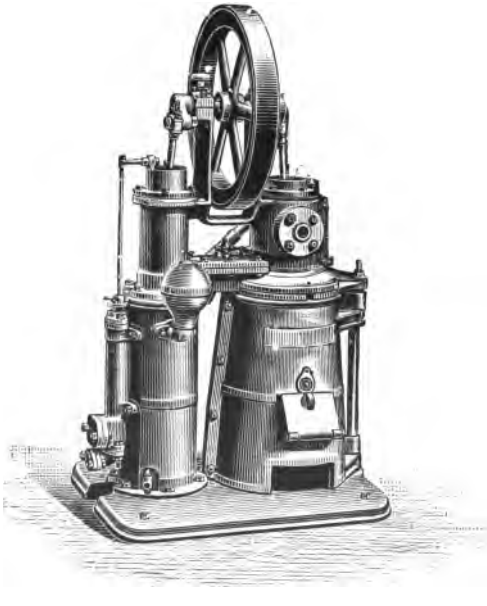


Fig. 1624

As will be seen from the accompanying engraving, Fig. 1624, the engine consists of a compression cylinder and a power cylinder (respectively right and left) with their plungers, and a regenerator. The lower portion of the compression cylinder is kept cool by water circulated around it, whilst the lower portion of the power cylinder is kept hot, by the action of the fire on the heater. The compression plunger nearly reaches the base of the engine, but is a trifle smaller than the interior of the cooler, leaving a thin space for the air to pass down and become thoroughly cooled. The power piston is also of sufficient length to nearly touch the heater at the lower part of its stroke, and both it and the heater, are so formed as to present a small annular supply of air to the action of the fire, so that it may be very rapidly heated. The telescope or quill forms a small annular passage for the air to pass down on its way from the compression cylinder to the power cylinder.

A certain quantity of water must be supplied to the cooler—by gravitation or otherwise—to keep it cool, and, as the water is uncontaminated, it may be passed by the pump through the cooler, before it is delivered to the tank or other destination.

A recent improvement, adopted in all engines of this type, consists in constructing the heater in halves, for facility in replacing it when burnt out, without returning the engine to the works.

PRICES OF HOT AIR ENGINES, Fig. 1624.

| | | |
|---|---|---|
| Effective horse power .. .. .. .. .. .. | ½ | 1 |
| Price of Engine .. .. .. .. .. .. .. | £45 | £75 |
| Approximate weight .. .. .. .. .. tons | ½ | 1¼ |

**TURBINES AND WATER WHEELS.**—Water power may be defined as the utilization of water falling through space, the power being measured by the weight of water falling in a given time, multiplied by the space fallen through, or, in other words, the height of fall. The product of those two factors is the power in foot pounds, which, divided by 33,000, gives the theoretical horse power developed.

Another convenient rule is to multiply the number of cubic feet of water falling per minute, by the height of fall in feet; the product divided by 706 gives the actual brake horse power based on an efficiency of 75 per cent. Modifications of this rule also give, respectively, the number of cubic feet of water per minute required to develop a given horse power, or the height of fall for a given volume of water and brake horse power.

**Selection of motor.**—The following illustrations and descriptions of a few types may serve as some guide to those who are not familiar with this class of machinery, towards a decision on the class of motor to be put down, but attention is directed to the fact that there is no turbine or water wheel which gives the best result under **all** conditions and, simple as the above formulæ are, errors are easily made even when the rules, referred to later on and in Section VII, have been correctly applied. These errors may arise from several causes, familiar enough to those who have experience with water motors. Amongst others may be mentioned: Insufficient allowance for differences in the levels of the head and tail races and the selection of a motor which cannot work satisfactorily under those conditions. Throttling in flumes or pipes and errors in gradients of these. Inconvenient arrangements in regard to foundations, transmission of power, &c. Advice on these and other points will be given if the requisite data is furnished.

Before referring to the types of motors which may be expected to give good results under the different conditions mentioned, it may be well to point out that, where the supply of motive power is practically unlimited, as it is in many parts of Europe and America, the simplest form of motor solidly built, may be more economical to the user than one of more costly construction.

**Efficiency of turbines.**—A good turbine may be relied upon for an efficiency of 75 per cent. Some types will not reach this, but almost any may be expected to yield from 60 to 80 per cent. of the water power.

**Efficiency of waterwheels.**—According to the investigations of M. Poncelet and M. Morin, the yield, in theoretical power, obtained from the different types is: **Overshot wheels**, 60 to 80 per cent. **Breast wheels**, 45 to 50 per cent. **Undershot wheels**, 27 to 30 per cent., so that the efficiency may be taken to range from 30 to 70 per cent. For prices of water wheels see pages 90, 96, 97.

**Measurement of power.**—Tables relating to this and other matters connected with installations for water power, will be found in Section VII. but the following notes and tables are given with a view to saving further reference.

In existing installations the man in charge of the shuttle usually knows what quantity of water passes through it in a given time, and his statement is easily checked by the well known rule for ascertaining the discharge through orifices. The most correct method however is that indicated in Fig. 1625.

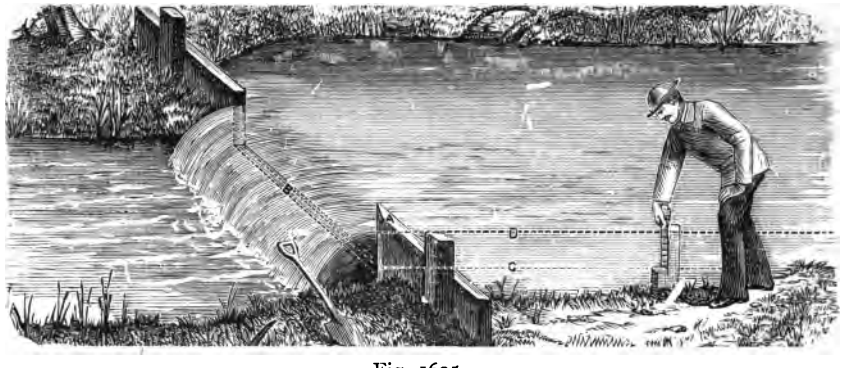



Fig. 1625.

The notched weir or tumbling bay shown in the engraving, must be wide and deep enough to pass all the water to be measured. The bottom board **B** is level and is fixed at a height which will give a fall of not less than six inches on the down stream side; the top edge of this board, as well as the vertical edges of the notch, are bevilled from the upstream side to present a sharp edge on that side, as shown at **A**, and the structure is made water tight with puddle. A stake is fixed about 6 feet above the weir, level with the top of the longitudinal board **B**, and the dotted lines **C** and **D** represent respectively, the level of the water when passing over the weir and that of the surface, &c. The measurement between **C** and **D** represents the number of inches flowing over the weir; this, multiplied by the number of inches between the notches and by the proper figures in the following table, gives the number of cubic feet of water delivered per minute over a weir of any length.

TABLE FOR ESTIMATING THE CUBIC FEET PER MINUTE PER INCH OF LENGTH OF WEIR.

| Inches Depth on Weir. | FRACTIONS OF AN INCH. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | $\frac{1}{8}$ | $\frac{1}{4}$ | $\frac{3}{8}$ | $\frac{1}{2}$ | $\frac{5}{8}$ | $\frac{3}{4}$ | $\frac{7}{8}$ |
| 0 | 0 | .01 | .05 | .09 | .14 | .20 | .26 | .33 |
| 1 | .40 | .47 | .55 | .65 | .74 | .83 | .93 | 1.03 |
| 2 | 1.14 | 1.24 | 1.36 | 1.47 | 1.59 | 1 71 | 1.83 | 1.96 |
| 3 | 2.09 | 2.23 | 2.36 | 2.50 | 2.63 | 2.78 | 2.92 | 3.07 |
| 4 | 3.22 | 3.37 | 3.52 | 3.68 | 3.83 | 3.99 | 4.16 | 4.32 |
| 5 | 4.50 | 4.67 | 4.84 | 5.01 | 5.18 | 5.36 | 5.54 | 5.72 |
| 6 | 5.90 | 6.09 | 6.18 | 6.47 | 6.65 | 6.85 | 7.05 | 7.25 |
| 7 | 7.44 | 7.64 | 7.84 | 8.05 | 8.25 | 8.45 | 8.66 | 8.86 |
| 8 | 9.10 | 9.31 | 9.52 | 9.74 | 9.96 | 10.18 | 10.40 | 10.62 |
| 9 | 10.86 | 11.08 | 11.32 | 11.54 | 11.77 | 12.00 | 12.23 | 12.47 |
| 10 | 12.71 | 13.05 | 13.19 | 13.43 | 13.67 | 13.93 | 14.16 | 14.42 |
| 11 | 14.67 | 14.92 | 15.18 | 15.43 | 15.67 | 15.96 | 16.20 | 16.46 |
| 12 | 16.73 | 16.99 | 17.26 | 17.52 | 17.78 | 18.05 | 18.32 | 18.58 |
| 13 | 18.87 | 19.14 | 19.42 | 19.69 | 19.97 | 20.24 | 20.52 | 20.80 |
| 14 | 21.09 | 21.37 | 21.65 | 21.94 | 22.22 | 22.51 | 22.79 | 23.08 |
| 15 | 23.38 | 23.67 | 23.97 | 24.26 | 24.56 | 24.86 | 25.16 | 25.46 |
| 16 | 25.76 | 26.06 | 26.36 | 26.66 | 26.97 | 27.27 | 27.58 | 27.89 |
| 17 | 28.20 | 28.51 | 28.82 | 29.14 | 29.45 | 29.76 | 30.08 | 30.39 |
| 18 | 30.70 | 31.02 | 31.34 | 31.66 | 31.98 | 32.31 | 32.63 | 32.96 |
| 19 | 33.29 | 33.61 | 33.94 | 34.27 | 34.60 | 34.94 | 35.27 | 35.60 |
| 20 | 35.94 | 36.27 | 36.60 | 36.94 | 37.28 | 37.62 | 37.96 | 33.31 |
| 21 | 38.65 | 39.00 | 39.34 | 39.69 | 40.04 | 40.39 | 40.73 | 41.09 |
| 22 | 41.43 | 41.78 | 42.13 | 42.49 | 42.84 | 43.20 | 43.56 | 43.92 |
| 23 | 44.28 | 44.64 | 45.00 | 42.38 | 45.71 | 46.08 | 46.43 | 46.81 |
| 24 | 47.18 | 47.55 | 47.91 | 48.28 | 48.65 | 49.02 | 49.39 | 49.76 |

The velocity of current is easily ascertained, by taking the time occupied by a float passing through a distance of (say) 20 or 30 yards; a corked bottle immersed to the neck answers every purpose.

**Power developed.**—The following table, calculated on an efficiency of 75 per cent., gives the quantity of water in cubic feet per minute required for each horse power, when acting under different falls; for instance, if any available quantity of water be divided by the cubic feet required per horse power with a given fall, (as ascertained from the table), the quotient will be the horse power at command. Or conversely: with a given head, any proposed horse power multiplied by the number of cubic feet required per horse power (taken from the table), will give the number of cubic feet per minute required to produce the proposed horse power, with that head.

NUMBER OF CUBIC FEET REQUIRED PER H.P. PER MINUTE.

| Head in Feet. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .. | 710 | 355 | 237 | 178 | 142 | 118 | 101 | 88.8 | 78.9 |
| 10 | 71 | 64.5 | 59.3 | 54.6 | 50.8 | 47.3 | 44.5 | 41.7 | 39.5 | 37.4 |
| 20 | 35.5 | 33.8 | 32.3 | 30.9 | 29.6 | 28.4 | 27.3 | 26.3 | 25.3 | 24.5 |
| 30 | 23.7 | 22.9 | 22.2 | 21.5 | 20.9 | 20.3 | 19.7 | 19.2 | 18.7 | 18.2 |
| 40 | 17.8 | 17.3 | 16.9 | 16.5 | 16.1 | 15.8 | 15.4 | 15.1 | 14.8 | 14.5 |
| 50 | 14.2 | 13.9 | 13.7 | 13.4 | 13.1 | 12.9 | 12.7 | 12.5 | 12.2 | 12.0 |
| 60 | 11.8 | 11.6 | 11.4 | 11.3 | 11.1 | 10.9 | 10.8 | 10.6 | 10.4 | 10.3 |
| 70 | 10.1 | 10.0 | 9.86 | 9.72 | 9.59 | 9.47 | 9.34 | 9.22 | 9 11 | 8.99 |
| 80 | 8.88 | 8.77 | 8.66 | 8.55 | 8.45 | 8.35 | 8.25 | 8.15 | 8.06 | 7.97 |
| 90 | 7.89 | 7.80 | 7.72 | 7.63 | 7.55 | 7.47 | 7.39 | 7.32 | 7.24 | 7.17 |

| Head in Feet. | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 7.1 | 6.45 | 5.73 | 5.46 | 5.08 | 4.73 | 4.43 | 4.17 | 3.95 | 3.74 |
| 200 | 3.55 | 3.38 | 3.23 | 3.09 | 2.96 | 2.84 | 2.73 | 2.63 | 2.53 | 2.45 |
| 300 | 2.37 | 2.29 | 2.22 | 2.15 | 2.09 | 2.03 | 1.97 | 1.92 | 1.87 | 1.82 |
| 400 | 1.78 | 1.73 | 1.69 | 1.65 | 1.61 | 1.58 | 1.54 | 1.51 | 1.48 | 1.45 |
| 500 | 1.42 | 1.39 | 1.37 | 1.34 | 1.31 | 1.29 | 1.27 | 1.25 | 1.22 | 1.20 |
| 600 | 1.18 | 1.16 | 1.14 | 1.13 | 1.11 | 1.09 | 1.08 | 1.06 | 1.04 | 1.03 |
| 700 | 1.01 | 1.00 | .986 | .912 | .959 | .947 | .934 | .922 | .911 | .899 |
| 800 | .888 | .877 | .866 | .855 | .845 | .835 | .825 | .815 | .806 | .797 |
| 900 | .788 | .780 | .772 | .763 | .755 | .747 | .739 | .732 | .724 | .717 |

**Arrangement of races.**—It is essential that the head water should reach the turbine as clear as possible of refuse matter, and the arrangement shown in Fig. 1626 (with necessary modifications) may be regarded as typical, although this turbine is of the low fall type illustrated by Figs. 1627 and 1628.

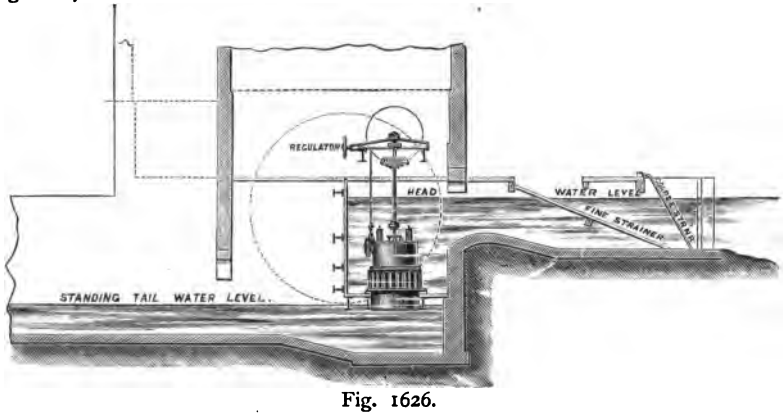



Fig. 1626.

The strainers are fixed at an angle of 45 to 60 degrees to guide the floating debris to the surface, where it is easily removed. The outer strainer is formed of bars, spaced about 3 inches apart, to arrest the coarser matter; the bars for the inner strainer are lighter and much closer together, frequently about half an inch apart.

The cost of packing for shipment and delivery f.o.b. ranges from about 6 to 8 per cent.

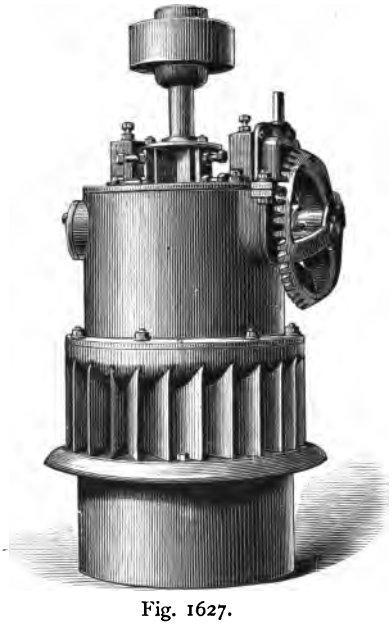


Fig. 1627.

Fig. 1628.

**LOW FALL TURBINES.—The "Hercules"** type represented by Fig. 1627, is adapted for falls of 5 to 20 feet; if the fall does not exceed 12 or 14 feet, the arrangement shown is that usually adopted, the turbine being fixed on a platform.

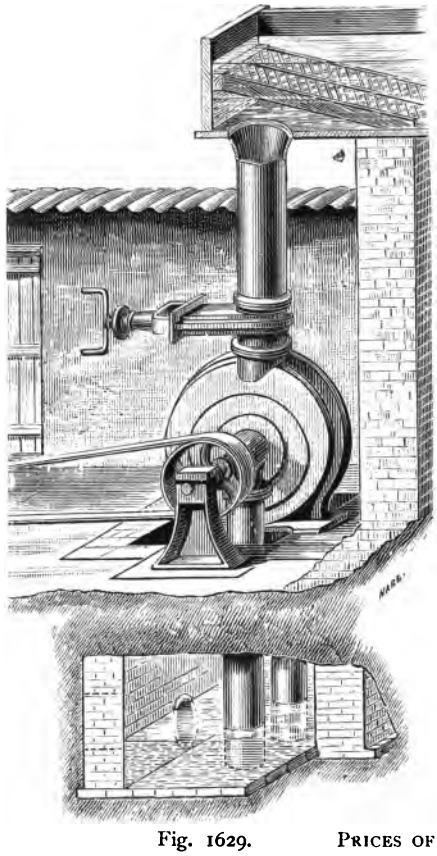
For falls exceeding about 14 feet the turbine should be surrounded by a casing and the price for most sizes of these will be found below. Care should be taken that the top of the turbine shall be covered when the head water is at its lowest level.

**The "New Victor"** type Fig. 1628, gives excellent results on low falls, where the volume of water is large and is steadily maintained, but it should not be used unless these conditions exist. The prices are the same as those for the "Hercules" types of equal diameters.

In both cases a portion of the fall may be utilized by suction.

PRICES OF TURBINES, Figs. 1627 and 1628.

| Fall of water .. feet | 6 | 8 | 10 | 12 | 14 | 16 | 20 |
|---|---|---|---|---|---|---|---|
| Price of turbine, 10 h.p. | £80 | £60 | £50 | £50 | £40 | £40 | £35 |
| ,, case .. .. | £65 | £45 | £40 | £40 | £35 | £35 | £30 |
| ,, turbine, 15 h.p. | £90 | £70 | £60 | £60 | £50 | £50 | £40 |
| ,, case .. .. | £75 | £55 | £45 | £45 | £40 | £40 | £35 |
| ,, turbine, 20 h.p. | £110 | £90 | £70 | £60 | £60 | £50 | £40 |
| ,, case .. .. | £92 | £75 | £55 | £45 | £45 | £40 | £35 |
| ,, turbine, 30 h.p. | £165 | £110 | £90 | £80 | £70 | £60 | £50 |
| ,, case .. .. | .. | £85 | £75 | £65 | £55 | £45 | £40 |
| ,, turbine, 40 h.p. | £200 | £135 | £110 | £90 | £80 | £70 | £60 |
| ,, case .. .. | .. | £102 | £85 | £75 | £65 | £55 | £45 |
| ,, turbine, 50 h.p. | £240 | £165 | £120 | £110 | £90 | £80 | £70 |
| ,, case .. .. | .. | .. | £92 | £85 | £75 | £65 | £55 |
| ,, turbine, 75 h.p. | £510 | £240 | £165 | £135 | £110 | £110 | £80 |
| ,, case .. .. | .. | .. | .. | £102 | £92 | £85 | £65 |
| ,, turbine, 100 h.p. | .. | £380 | £240 | £200 | £135 | £120 | £90 |
| ,, case .. .. | .. | .. | .. | .. | £102 | £92 | £75 |



**VORTEX HORIZONTAL SHAFT TURBINES.**—As will be seen from Fig. 1629, the arrangement differs from that shown in the previous engravings, the driving shaft, in this case, being horizontal.

The supply pipes may be fixed vertically, as shown, or horizontally, and the advantage from the suction is obtained, provided that the height of the turbine above the bottom of the discharge pipe, which is immersed in the tail race, does not exceed 25 feet.

The engraving indicates an arrangement which has frequently been adopted, where a water wheel does not furnish the power required, and has been taken out. The water wheel pit is then converted into a turbine house and advantage is taken of the suction in the pipes discharging with the tail race, as already referred to.

Turbines of this type are made of all powers from 4 to 150 horse power and for falls varying from 10 to 200 feet, so that if the powers required differ from those mentioned in the table, they can readily be obtained.

The prices are for the turbines without pipes or other accessories, excepting the length of main driving shaft requisite for carrying a pulley and the outer bearing for the shaft.

Fig. 1629. PRICES OF VORTEX TURBINES, Fig. 1629.

| Fall of water .. feet | 14 | 20 | 30 | 40 | 50 | 60 | 70 |
|---|---|---|---|---|---|---|---|
| Price of turbine 6 h.p. | £75 | £68 | £57 | £54 | £53 | £49 | £48 |
| ,, ,, 8 ,, | £81 | £74 | £65 | £62 | £58 | £57 | £56 |
| ,, ,, 10 ,, | £97 | £79 | £73 | £66 | £63 | £62 | £61 |
| ,, ,, 15 ,, | £148 | £103 | £79 | £75 | £70 | £68 | £67 |
| ,, ,, 20 ,, | £173 | £132 | £98 | £87 | £85 | £79 | £77 |
| ,, ,, 30 ,, | £236 | £155 | £132 | £115 | £98 | £96 | £94 |
| ,, ,, 40 ,, | .. | £215 | £152 | £137 | £127 | £116 | £107 |
| ,, ,, 50 ,, | .. | £245 | £178 | £154 | £146 | £138 | £130 |

**GIRARD TURBINES.**—In the engraving Fig. 1630, a portion of the casing which surrounds the wheel is removed to show the internal construction of the motor. This type of turbine is largely used—especially on the Continent of Europe—for medium and high falls, and where it is convenient to have a comparatively low speed of main shaft. Apart from the high duty they yield, the relative useful effect is practically the same, whether the gate is regulated to admit the full or a diminished supply of water and, for this reason, the Girard turbine may be confidently selected for use where there are great fluctuations, either in the volume of water available or in the load on the motor. The convenience of driving direct from the pulley on the turbine shaft, (without the intervention of gear) is also frequently worth consideration, but if desired, the turbine is arranged to work vertically and, in that case, about 4 feet of vertical shaft above the casing is provided.

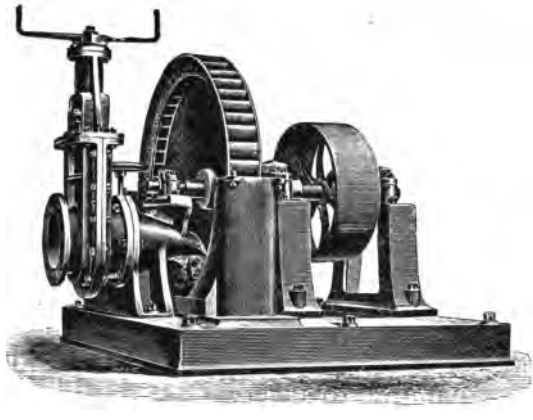


Fig. 1630.

As this class of turbine does not work by suction, it must be fixed at as low a point as convenient, if the full head of water available is to be used.

The following prices include the base plate and standards, pedestals with gun metal bearings for the main shaft, and wrought or cast iron cover for the wheel. The extra cost of the pulley or other driving gear, (if it is to be supplied with the turbine) is in proportion with the dimensions, &c. of what is required.

Special quotations should be obtained for turbines of higher powers or to fulfil conditions differing from those referred to in the following table.

PRICES OF GIRARD TURBINES, Fig. 1630.

| Fall of water .. feet | 75 | 100 | 150 | 200 | 250 | 300 | 400 |
|---|---|---|---|---|---|---|---|
| Price of turbine, 10 h.p. | £55 | £50 | £40 | £50 | £60 | £63 | £78 |
| ,, ,, 20 ,, | £84 | £62 | £55 | £66 | £75 | £78 | £113 |
| ,, ,, 30 ,, | £96 | £88 | £64 | £70 | £80 | £100 | £115 |
| ,, ,, 40 ,, | £103 | £100 | £72 | £75 | £100 | £104 | £118 |
| ,, ,, 50 ,, | £108 | £105 | £84 | £88 | £102 | £105 | £120 |
| ,, ,, 60 ,, | £113 | £111 | £97 | £101 | £99 | £115 | £121 |
| ,, ,, 100 ,, | £165 | £126 | £120 | £121 | £123 | £127 | £130 |
| ,, ,, 140 ,, | £203 | £176 | £130 | £132 | £138 | £140 | £185 |

The cost of packing for shipment and delivery f.o.b. ranges from 5 to 10 per cent.

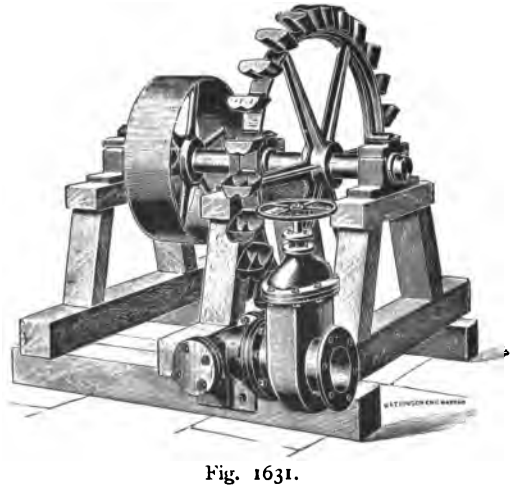


Fig. 1631.

**THE PELTON WHEEL,** Fig. 1631, so largely and successfully used with the high falls met with in California and other parts of the United States of America, is the cheapest and most simple turbine made, and, for this reason, may frequently be adopted with advantage for falls very much less than the lowest (100 feet) mentioned in the accompanying table, rather than one of more costly and less simple construction.

The buckets and nozzles are replaced in a few minutes when they become worn, and this form of turbine works quite well with unstrained water from a mine, or after it has been used for ore dressing. In one instance within the writer's knowledge, the drainage water from the mine is used for motive power for ore dressing, at three different levels between the exit from the mine and the discharge into the river below.

The turbine frame may be supported on timber, as shown, or on masonry or on a wrought iron structure. For the higher powers, masonry is usually the cheapest and the best. The wheel cover may be in wrought iron and sent out with the turbine, but a plain timber casing—easily made by the purchaser—is quite as good.

**The prices** of Pelton wheels include the wheel and main shaft, pedestal bearings, collars, steel nozzle with three interchangeable tips to give variations in power, and the shut off valve for connection to the supply main.

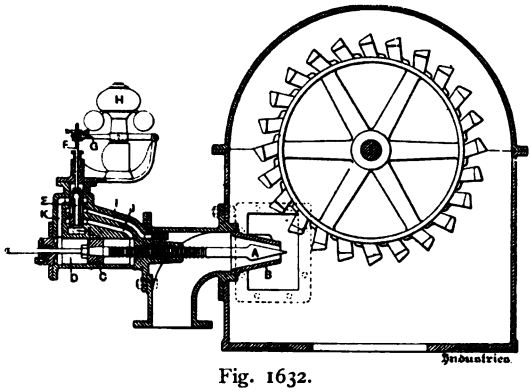


Fig. 1632.

**Case and Cover for Pelton Wheels.**—The diagram Fig. 1632 represents the arrangement usually adopted when the wheel is made complete with metallic casing, and clearly indicates the mode in which the inlet of water is regulated, also a governor, but this is rarely used and the cost of it is not included in any of the subjoined prices.

The prices for casings include all the accessories above referred to, as well as the bed or frame to carry the turbine, the cover and the supports for three pedestal bearings.

**Light packages.**—At an extra cost of 10 to 15 per cent. the larger wheels are made in segments, weighing not more than 300 lbs., for transport by mule.

**Pulleys or gear.**—The turbines are sent out complete with plain or grooved pulleys, spur, bevil or worm wheels, and are charged in proportion with what may be necessary to fulfil the conditions required.

PRICES OF PELTON WHEELS, Fig. 1631.

| Fall of water .. feet | 100 | 180 | 260 | 350 | 500 | 600 | 700 |
|---|---|---|---|---|---|---|---|
| Price of wheel 10 h.p. | £40 | £25 | £17 | £19 | £12 | £14 | £16 |
| ,, case, &c. .. | £60 | £37 | £25 | £27 | £17 | £20 | £23 |
| ,, wheel 20 h.p. | £46 | £40 | £25 | £27 | £20 | £21 | £22 |
| ,, case, &c. .. | £70 | £61 | £38 | £40 | £30 | £31 | £33 |
| ,, wheel 30 h.p. | £62 | £48 | £42 | £35 | £29 | £22 | £23 |
| ,, case, &c. .. | £100 | £72 | £63 | £51 | £43 | £33 | £35 |
| ,, wheel 40 h.p. | £77 | £55 | £42 | £36 | £30 | £31 | £27 |
| ,, case, &c. .. | £126 | £87 | £63 | £53 | £44 | £44 | £40 |
| ,, wheel 50 h.p. | £78 | £55 | £42 | £43 | £37 | £31 | £32 |
| ,, case, &c. .. | £128 | £88 | £66 | £67 | £54 | £47 | £50 |
| ,, wheel 100 h.p. | £102 | £82 | £58 | £50 | £44 | £46 | £40 |
| ,, case, &c. .. | £165 | £130 | £90 | £75 | £67 | £69 | £60 |
| ,, wheel 200 h.p. | £132 | £109 | £88 | £70 | £60 | £54 | £55 |
| ,, case, &c. .. | £115 | £175 | £144 | £115 | £94 | £82 | £84 |
| ,, wheel 400 h.p. | £149 | £139 | £120 | £125 | £74 | £75 | £61 |
| ,, case, &c. .. | £245 | £227 | £196 | £204 | £120 | £122 | £96 |
| ,, wheel 500 h.p. | £165 | £141 | £123 | £127 | £98 | £80 | £76 |
| ,, case, &c. .. | £275 | £230 | £204 | £210 | £160 | £130 | £124 |

The cost of packing for shipment and delivery f.o.b. is about 7½ per cent.

**TURBINE PIPES.**—Information with reference to these will be found below and attention is directed to the advantage in strength, relatively with weight, of steel or wrought iron pipes.

**Steel pipes** are about one-fifth the weight of cast iron pipes of equal diameter and strength and their durability is proved by the fact that wrought iron pipes, which have been in use for more than 25 years are, practically, as good as when they were laid. They are commonly made of all diameters up to 5 feet and, as long lengths are almost invariably made up of different diameters, the smaller diameters can be nested in the larger and so effect a large saving in cost of freight. In some cases the flanges or sockets are sent loose with an ample supply of rivets for rivetting up at destination.

**CAST IRON SOCKET AND FLANGED PIPES.**—The approximate weights and prices of pipes and connections refer solely to the dimensions specified, and any other dimensions must be subject to special quotations. Many forms of connections are omitted from the lists but will be made when desired.

**The prices** necessarily fluctuate with the cost of materials and labour, and are given merely as a basis for approximate estimate and to avoid loss of time in correspondence.

**For small quantities** of pipes and connections supplied from London stock, or for special lengths, some addition must be made to the prices in the following lists.

**Coating** with Dr. Angus Smith's patent solution costs about 3 per cent. on the price of the pipes.

**Boring and turning** the ends of socket pipes costs about 4 or 5 per cent.

**Dimensions of flanges.**—If pipes are required to connect with existing flanges, templates of them should be sent showing the dimensions of the existing flanges and the sizes and positions of bolt holes, or sketches thereof with figured dimensions; also instructions, if necessary, as to facing.

**Testing.**—The pipes now referred to are tested by hydraulic pressure equal to 300 feet head of water.

**Weights.**—These will be adhered to as closely as practicable, but cannot be guaranteed.

PRICES OF CAST IRON FLANGED PIPES.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Internal diameter | .. | inch | 2 | 2½ | 3 | 3½ | 4 | 4½ |
| Thickness .. | .. | ,, | 9/32 | 11/32 | 5/16 | 11/32 | 3/8 | 13/32 |
| ,, .. | .. | m/m | 7·14 | 8·73 | 7·94 | 8·73 | 9·52 | 10·32 |
| Length when laid | .. | feet | 6 | 6 | 9 | 9 | 9 | 9 |
| ,, ,, | .. | metres | 1·829 | 1·829 | 2·134 | 2·134 | 2·134 | 2·134 |
| Weight per length | .. | cwts. | 0 1 21 | 0 2 11 | 1 0 0 | 1 0 21 | 1 1 21 | 1 3 0 |
| ,, per metre | .. | kilog. | 12·15 | 16·60 | 18·50 | 22·00 | 26·62 | 32·41 |
| Price per yard .. | .. | .. | 1/7 | 1/11 | 2/1 | 2/4 | 2/9 | 3/4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Internal diameter | .. | inch | 5 | 6 | 7 | 8 | 10 | 12 |
| Thickness .. | .. | ,, | 7/16 | ½ | ½ | 17/32 | ⅝ | 11/16 |
| ,, .. | .. | m/m | 11·11 | 12·70 | 12·70 | 13·49 | 15·88 | 17·46 |
| Length when laid | .. | feet | 9 | 9 | 9 | 9 | 9 | 9 |
| ,, ,, | .. | metres | 2·134 | 2·134 | 2·134 | 2·134 | 2·134 | 2·134 |
| Weight per length | .. | cwts. | 2 0 14 | 2 3 0 | 3 1 7 | 3 3 14 | 5 3 14 | 7 3 0 |
| ,, per metre | .. | kilog. | 39·35 | 50·95 | 61·35 | 71·76 | 108·80 | 143·52 |
| Price per yard .. | .. | .. | 4/- | 5/1 | 6/8 | 7/9 | 11/9 | 15/6 |

**CONNECTIONS FOR FLANGE PIPES** such as **elbows, T pieces, flange sockets, blank flanges, &c.**, range in price from about £10 10 0 per ton for the large sizes to £12 0 0, for the smaller sizes.

PRICES FOR FACING FLANGES OF PIPES, BENDS, T PIECES, AND OTHER CONNECTIONS.

| | | | | | | |
|---|---|---|---|---|---|---|
| Internal diameter .. .. .. | inches | 2½ to 4½ | 5 to 6 | 7 to 8 | 9 to 12 |
| Price for facing strip, pipes .. .. .. | | -/7 | -/9 | 1/3 | 1/11 |
| ,, ,, ,, connections .. .. .. | | 1/3 | 1/6 | 2/8 | 3/9 |
| ,, ,, across flange, pipes .. .. .. | | -/11 | 1/3 | 1/11 | 2/8 |
| ,, ,, ,, connections .. .. | | 1/9 | 2/6 | 3/9 | 5/8 |

PRICES OF CAST IRON SOCKET PIPES AND CONNECTIONS.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Internal diameter .. inch | 2 | 2½ | 3 | 3½ | 4 | 4½ |
| Thickness .. .. ,, | ¼ | 5/16 | 5/16 | 5/16 | 11/32 | 3/8 |
| Ditto .. .. .. m/m | 6.35 | 7.94 | 7.94 | 7.94 | 8.73 | 9.52 |
| Length when laid .. feet | 6 | 9 | 9 | 9 | 9 | 9 |
| Ditto ditto .. metres | 1.829 | 2.134 | 2.134 | 2.134 | 2.134 | 2.134 |
| Weight per length .. cwts. | 0 1 14 | 0 3 0 | 0 3 14 | 1 0 14 | 1 1 14 | 1 2 14 |
| Ditto metre .. kilog. | 10.40 | 13.88 | 16.20 | 20.83 | 25.46 | 30 10 |
| Price per yard .. .. .. | 1/1 | 1/3 | 1/5 | 1/10 | 2/3 | 2/6 |
| Lead for joint .. .. lbs. | 1.7 | 2 | 2.4 | 3 | 3.6 | 5.3 |
| Price of elbow .. .. each | 1/10 | 2/6 | 3/1 | 4/- | 5/- | 6/2 |
| Do. ¼ bend .. .. ,, | 2/6 | 3/3 | 3/5 | 4/5 | 5/9 | 8/- |
| Do. T piece .. ,, | 4/4 | 5/10 | 7/2 | 8/1 | 9/2 | 10/1 |
| Do. branch .. .. ,, | 4/11 | 6/6 | 7/6 | 9/9 | 11/- | 12/- |
| Do. collar .. .. ,, | 1/6 | 2/2 | 2/5 | 2/8 | 3/3 | 3/6 |
| Do. cap .. .. ,, | -/9 | -/10 | 1/4 | 1/10 | 2/1 | 2/4 |
| Do. syphon and cover ,, | 15/9 | 19/6 | 21/3 | 21/9 | 22/6 | 23/6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Internal diameter .. inch | 5 | 6 | 7 | 8 | 10 | 12 |
| Thickness .. .. ,, | 13/32 | 13/32 | 7/16 | 15/32 | 9/16 | 17/32 |
| Ditto .. .. m/m | 10.32 | 10.32 | 11.11 | 11.91 | 14.29 | 13.49 |
| Length when laid .. feet | 9 | 9 | 9 | 9 | 9 | 9 |
| Ditto ditto .. metres | 2.134 | 2.134 | 2.134 | 2.134 | 2.134 | 2.134 |
| Weight per length .. cwts. | 1 3 14 | 2 1 14 | 2 3 14 | 3 1 14 | 4 3 0 | 5 3 21 |
| Ditto metre .. kilog. | 34.72 | 44.00 | 53.24 | 62.50 | 88.00 | 110.00 |
| Price per yard .. .. .. | 2/10 | 3/7 | 4/9 | 5/6 | 7/9 | 9/9 |
| Lead for joint .. .. lbs. | 6 | 8.2 | 8.7 | 9.9 | 14.9 | 17.2 |
| Price of elbow .. .. each | 7/2 | 9/6 | 13/2 | 14/8 | 24/9 | .. |
| Do. ¼ bend .. .. ,, | 9/6 | 13/8 | 19/9 | 22/2 | 33/9 | 36/- |
| Do. T piece .. ,, | 11/4 | 15/3 | 21/6 | 28/5 | 38/3 | 49/6 |
| Do. branch .. .. ,, | 13/1 | 15/6 | 27/- | 29/9 | 41/9 | 51/3 |
| Do. collar .. .. ,, | 3/7 | 5/2 | 6/5 | 7/1 | 9/- | 12/3 |
| Do. cap .. .. ,, | 2/6 | 3/1 | 4/2 | 5/4 | 7/9 | 13/- |
| Do. syphon and cover ,, | 25/- | 32/6 | 46/9 | 48/6 | 63/- | 78/9 |

**Connections for other sections** of metal or special forms range in price from about £10 to £12 per ton.

Fig. 1633.

Fig. 1634.

## RIVETTED STEEL PIPES WITH SOCKET OR FLANGED JOINTS

are made of any length up to about 20 feet and of any diameter from 3 to 60 inches. These pipes are usually coated with a composition which protects them from corrosion and has no injurious effect on water.

**Weight and strength.**—As stated at p. 91 the weight is about one-fifth that of cast iron pipes of equal dimensions and proof strength.

**Thickness.**—Unless otherwise specified the pipes are made of the lightest section mentioned in the subjoined list.

**Prices.**—These indicate approximately the cost of pipes 20 ft. long of the diameters and sections commonly used; the prices of intermediate and larger sizes are in proportion with the dimensions.

**Socket pipes,** Fig. 1633.—The joints are made in the same way as those for cast iron socket pipes; the prices (without lead and yarn for joints) do not differ much from those of flanged pipes with bolts, &c.

**Flanged pipes,** Fig. 1634.—Bolts, nuts and India-rubber washers are supplied for the joints.

PRICES OF RIVETTED STEEL SOCKET OR FLANGED PIPES.

| Internal diameter inches | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 24 | 27 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness .. .. ,, | .092 | .092 | .104 | .104 | .116 | .116 | .128 | .144 | .160 | .176 | .192 |
| Ditto .. .. W.G. | 13 | 13 | 12 | 12 | 11 | 11 | 10 | 9 | 8 | 7 | 6 |
| Price .. .. per ft. | 2/8 | 3/4 | 4/1 | 4/9 | 5/11 | 6/9 | 8/2 | 9/8 | 11/11 | 14/3 | .. |
| If one gauge thicker ,, | 2/9 | 3/5 | 4/4 | 5/1 | 6/7 | 7/4 | 8/10 | 10/3 | 13/- | .. | .. |
| If two gauges ,, ,, | 3/- | 3/8 | 4/10 | 5/11 | 7/2 | 8/- | 9/5 | 11/4 | .. | .. | .. |
| If three ,, ,, ,, | .. | .. | .. | 6/6 | 7/9 | 8/7 | 10/6 | .. | .. | .. | .. |
| If $\frac{3}{16}$ inch thick ,, | .. | .. | .. | 8/5 | 9/3 | 10/1 | 10/11 | 11/9 | 13/6 | 15/- | 16/6 |

**STEEL OR WROUGHT IRON LAP-WELDED TUBES,** for higher pressures than those last referred to, are usually made with plain ends ready for the sockets or flanges to be fixed at destination, or with the "Kimberley" socket joint.

This, or another (loose) socket also for lead joint, is included in the subjoined prices, but other kinds of joints are frequently made of special design to suit the purpose for which the pipes are to be used and—the conditions being clearly defined—there is no difficulty in providing a suitable joint.

The prices of pipes of diameters commonly used will be found below; but it will be understood that intermediate and larger diameters are made and that prices are in proportion with dimensions—for instance: the price of pipes 23 inches diameter and $\frac{1}{2}$ inch thick is 44/9 per foot.

PRICES OF LAP-WELDED PIPES.

| Internal diam. ins. | 11 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 33 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\frac{3}{16}$ in. thick per ft. | 7/11 | 8/7 | 10/- | 11/4 | 12/9 | 14/- | .. | .. | .. | .. | .. | .. | .. |
| $\frac{1}{4}$ in. ,, ,, | 10/6 | 11/6 | 13/4 | 15/4 | 17/3 | 19/1 | 21/- | .. | .. | .. | .. | .. | .. |
| $\frac{5}{16}$ in. ,, ,, | 13/3 | 14/5 | 16/9 | 19/2 | 21/7 | 24/- | 26/4 | 28/9 | .. | .. | .. | .. | .. |
| $\frac{3}{8}$ in. ,, ,, | 16/- | 17/5 | 20/3 | 23/1 | 25/11 | 28/8 | 31/6 | 34/4 | 37/2 | .. | .. | .. | .. |
| $\frac{7}{16}$ in. ,, ,, | 18/9 | 20/5 | 23/10 | 27/2 | 30/6 | 33/10 | 37/2 | 40/6 | 43/10 | 47/2 | 50/6 | .. | .. |
| $\frac{1}{2}$ in. ,, ,, | 21/7 | 23/6 | 27/5 | 31/3 | 35/2 | 39/- | 42/10 | 46/9 | 50/7 | 54/6 | 58/5 | 64/2 | 70/- |
| $\frac{9}{16}$ in. ,, ,, | 24/5 | 26/7 | 31/1 | 35/5 | 39/10 | 44/3 | 48/6 | 52/10 | 57/2 | 61/6 | 65/10 | 72/4 | 78/10 |
| $\frac{5}{8}$ in. ,, ,, | 27/5 | 29/11 | 34/9 | 39/9 | 44/9 | 49/8 | 54/7 | 59/6 | 64/5 | 69/3 | 74/2 | 81/7 | 89/- |

**STEEL AND WROUGHT IRON TUBES WITH LOOSE FLANGES,** Fig. 1635, are so much lighter than cast iron pipes of equal diameter and strength that they may be used with advantage for conveying water and compressed air for mining and for many other purposes, where cost of transport and handling, form important items in the total cost.

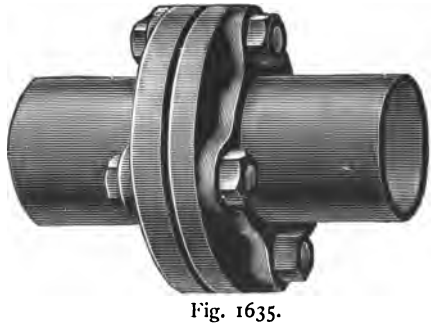


Fig. 1635.

**The tubes** are lap-welded and are made in lengths of from 11 to 19 feet according to diameter; every tube is tested to a pressure of 1000 lbs. per square inch, and may be used for working pressures up to 300 lbs. per square inch.

**The flanges** are of steel or malleable iron and are sent on the tubes, or separately, as may be convenient and the subjoined prices include the bolts, india-rubber washers, &c. to form the joints.

**The thickness** is that generally used but it can be increased for tubes required for exceptional pressure.

**Branch service connections** are made but they vary so widely in details that prices cannot conveniently be tabulated.

PRICES OF STEEL AND WROUGHT IRON TUBES WITH FLANGES, Fig. 1635.

| Internal diameter .. .. inch | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 |
|---|---|---|---|---|---|---|---|---|
| Thickness .. decimals of inch | ·092 | ·104 | ·116 | ·128 | ·128 | ·144 | ·160 | ·160 |
| Do. Standard W.G. No. | 13 | 12 | 11 | 10 | 10 | 9 | 8 | 8 |
| Prices of Tubes .. per foot | -/10½ | 1/1 | 1/6 | 1/11 | 2/6 | 3/- | 3/9 | 4/6 |
| Do. Bends, steel .. each | 10/- | 12/- | 15/- | 18/- | 24/- | 30/- | 40/- | 50/- |
| Do. Elbows ,, .. ,, | 14/6 | 16/6 | 18/6 | 21/6 | 25/- | 30/- | 36/- | 42/- |
| Do. T pieces ,, .. ,. | 20/- | 22/- | 24/6 | 29/- | 33/6 | 40/- | 49/- | 56/- |
| Connecting or reducing pieces .. | 6/- | 8/- | 10/- | 12/- | 14/- | 17/- | 23/- | 27/- |

| Internal diameter .. .. inch | 5½ | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|
| Thickness .. decimals of inch | ·176 | ·176 | ·192 | ·192 | ·232 | ·252 | ·300 | ·300 |
| Do. Standard W.G. No. | 7 | 7 | 6 | 6 | 4 | 3 | 1 | 1 |
| Prices of Tubes .. per foot | 5/3 | 6/- | 8/- | 10/- | 13/- | 18/6 | 24/- | 28/- |
| Do. Bends .. .. each | 95/- | 80/- | 115/- | 165/- | 220/- | 280/- | 340/- | 400/- |
| Do. Elbows .. .. ,, | 48/- | 55/- | 70/- | 90/- | 105/- | 125/- | 150/- | 175/- |
| Do. T pieces .. .. ,, | 64/- | 74/- | 95/- | 120/- | 140/- | 165/- | 185/- | 210/- |
| Connecting or reducing pieces .. | 32/- | 37/- | 48/- | 60/- | 70/- | 85/- | 100/- | 120/- |

**SPECIAL STEEL PIPES** of the kinds indicated in Figs. 1633 to 1635 are usually made to fulfil special conditions in regard to the maximum pressure to be carried, the distance between supports, &c.; the proportions given in the foregoing lists are merely those which have hitherto been found to be in general demand.

**Rivetted steel pipes.**—For low pressures, pipes of large diameter are made of much lighter sections than those mentioned on the preceding page, and frequently without flanged or other joints, the ends being rivetted together when laid to form a continuous length, with corresponding reduction in the cost per foot.

**Welded and solid drawn tubes,** on the other hand, are made to withstand the highest pressures and are provided with flange, screwed collar, flush, or such other joints as may be required.

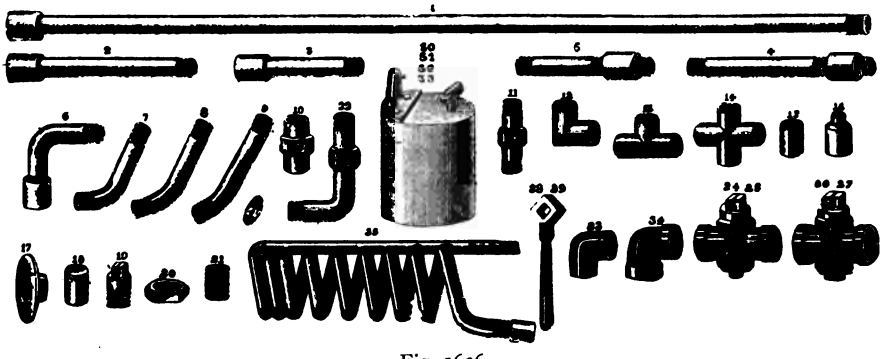


Fig. 1636.

**WROUGHT IRON TUBES AND CONNECTIONS** for gas, water, steam, compressed air, &c. The tubes are made in lengths up to about 14 feet and can be galvanized if required

**Tubes for steam** or for pressures exceeding about 50 lbs. per square inch are subject to a lower rate of discount than tubes for gas, or low pressures. The cost varies with the price of iron, but if the discount for gas tubes is 65 per cent., that for steam tubes will be about 50 per cent.

PRICES OF WROUGHT IRON GAS, WATER AND STEAM TUBES AND FITTINGS, FIG. 1636.

| No. | INTERNAL DIAMETER, INCHES | ¼ | | ⅜ | | ½ | | ¾ | | 1 | | 1¼ | | 1½ | | 1¾ | | 2 | | 2¼ | | 2½ | | 2¾ | | 3 | | 3½ | | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | s. | d. | s. | d. | s. | d. | s. | d. | s. | d. | s. | d. | s. | d. | s. | d. | s. | d. | s. | d | s. | d. | s. | d. | s. | d. | s. | d. | s. | d. |
| 1 | Tubes, 2 to 14, with sockets, pr ft. | 0 | 2½ | 0 | 3 | 0 | 4½ | 0 | 6 | 0 | 8½ | 1 | 0 | 1 | 3 | 1 | 6 | 1 | 9 | 2 | 7 | 3 | 3 | 4 | 0 | 4 | 6 | 5 | 6 | 7 | 0 |
| 2 | Pieces, 12 to 23½ inches each | 0 | 5 | 0 | 7 | 0 | 9 | 1 | 0 | 1 | 4 | 1 | 8 | 2 | 0 | 2 | 6 | 3 | 0 | 4 | 6 | 6 | 3 | 7 | 6 | 9 | 0 | 11 | 6 | 14 | 6 |
| 3 | Do. 3 to 11½ ,, ,, | 0 | 3 | 0 | 4 | 0 | 6 | 0 | 8 | 0 | 11 | 1 | 1 | 1 | 4 | 2 | 0 | 2 | 3 | 4 | 0 | 4 | 9 | 6 | 0 | 7 | 0 | 8 | 0 | 9 | 0 |
| 4 | Longscrews, 12 to 23½,, ,, | 0 | 7 | 0 | 9 | 0 | 11 | 1 | 2 | 1 | 6 | 2 | 0 | 2 | 6 | 3 | 3 | 4 | 0 | 5 | 6 | 7 | 0 | 8 | 6 | 10 | 0 | 12 | 6 | 15 | 6 |
| 5 | Do. 3 to 11½,, ,, | 0 | 5 | 0 | 7 | 0 | 8 | 0 | 10 | 1 | 0 | 1 | 3 | 2 | 0 | 2 | 6 | 3 | 0 | 4 | 6 | 5 | 6 | 6 | 6 | 7 | 6 | 8 | 6 | 10 | 0 |
| 6 | Bends .. .. .. ,, | 0 | 6½ | 0 | 7 | 0 | 8 | 0 | 11 | 1 | 3 | 1 | 9 | 2 | 3 | 3 | 3 | 4 | 3 | 6 | 6 | 10 | 0 | 12 | 0 | 16 | 0 | 25 | 0 | 32 | 6 |
| 7,8,9 | Springs, not socketed .. ,, | 0 | 5 | 0 | 6 | 0 | 7 | 0 | 9 | 0 | 11 | 1 | 4 | 1 | 8 | 2 | 6 | 3 | 3 | 5 | 6 | 7 | 6 | 10 | 0 | 12 | 0 | 19 | 0 | 26 | 0 |

## FITTINGS.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 11, | Socket-union, Pipe-union (11) | 2 | 0 | 2 | 6 | 3 | 0 | 4 | 0 | 5 | 6 | 6 | 9 | 8 | 0 | 9 | 0 | 10 | 0 | 12 | 0 | 14 | 0 | 16 | 0 | 18 | 0 | 22 | 0 | 28 | 0 |
| 12 | Elbows .. .. ..each | 0 | 6½ | 0 | 7 | 0 | 8 | 0 | 10 | 1 | 2 | 1 | 9 | 2 | 3 | 3 | 0 | 3 | 6 | 5 | 6 | 8 | 6 | 11 | 0 | 14 | 0 | 22 | 0 | 28 | 0 |
| 13 | Tees .. .. .. .. ,, | 0 | 6½ | 0 | 7 | 0 | 9 | 1 | 0 | 1 | 3 | 1 | 9 | 2 | 6 | 3 | 0 | 3 | 9 | 6 | 0 | 9 | 6 | 12 | 6 | 16 | 6 | 24 | 0 | 30 | 0 |
| 14 | Crosses .. .. .. ,, | 1 | 4 | 1 | 4 | 1 | 11 | 2 | 4 | 3 | 0 | 4 | 0 | 4 | 8 | 6 | 0 | 7 | 0 | 14 | 0 | 21 | 4 | 28 | 0 | 40 | 0 | 56 | 0 | 66 | 8 |
| 15 | Plain Sockets .. .. ,, | 0 | 1½ | 0 | 2 | 0 | 3 | 0 | 3½ | 0 | 4 | 0 | 6 | 0 | 7 | 0 | 9 | 1 | 0 | 1 | 6 | 2 | 6 | 3 | 0 | 3 | 6 | 5 | 0 | 6 | 0 |
| 16 | Diminished Sockets .. ,, | 0 | 3 | 0 | 4 | 0 | 5 | 0 | 6 | 0 | 7 | 0 | 9 | 0 | 11 | 1 | 1 | 1 | 3 | 2 | 0 | 3 | 0 | 4 | 0 | 5 | 0 | 7 | 0 | 9 | 0 |
| 17 | Flanges .. .. .. ,, | 0 | 9 | 0 | 10 | 1 | 0 | 1 | 2 | 1 | 4 | 1 | 6 | 1 | 9 | 2 | 0 | 2 | 6 | 3 | 9 | 5 | 0 | 6 | 9 | 8 | 6 | 10 | 0 | 11 | 6 |
| 18, 19 | Caps (18), Plugs (19) .. ,, | 0 | 3 | 0 | 3 | 0 | 4 | 0 | 5 | 0 | 6 | 0 | 8 | 0 | 10 | 1 | 0 | 1 | 3 | 2 | 0 | 2 | 6 | 3 | 6 | 4 | 9 | 7 | 0 | 10 | 0 |
| 20, 21 | Back Nuts (20), Nipples (21) ,, | 0 | 2 | 0 | 2 | 0 | 3 | 0 | 3½ | 0 | 4 | 0 | 6 | 0 | 8 | 0 | 10 | 1 | 0 | 1 | 9 | 2 | 3 | 3 | 0 | 3 | 6 | 4 | 6 | 5 | 6 |
| 22 | Union Bends .. .. ,, | 2 | 6 | 3 | 0 | 3 | 9 | 5 | 0 | 6 | 3 | 8 | 6 | 10 | 0 | 11 | 6 | 13 | 6 | 16 | 0 | 19 | 0 | 22 | 0 | 25 | 0 | 30 | 0 | 36 | 0 |
| 23 | Round Elbows .. .. ,, | 0 | 7 | 0 | 8 | 0 | 9 | 1 | 0 | 1 | 4 | 1 | 11 | 2 | 6 | 3 | 4 | 3 | 10 | 6 | 6 | 10 | 0 | 13 | 0 | 16 | 0 | 25 | 0 | 32 | 0 |
| 24 | Iron Main Cocks .. .. ,, | 2 | 3 | 2 | 9 | 3 | 6 | 4 | 6 | 6 | 6 | 8 | 6 | 11 | 0 | 14 | 0 | 18 | 0 | 27 | 0 | 36 | 0 | 44 | 0 | 50 | 0 | 75 | 0 | 90 | 0 |
| 25 | Do. with Brass Plugs .. ,, | .. | | 4 | 6 | 5 | 6 | 7 | 6 | 10 | 6 | 15 | 0 | 19 | 6 | 25 | 0 | 32 | 0 | 47 | 0 | 60 | 0 | 90 | 0 | 110 | 0 | 140 | 0 | 190 | 0 |
| 26 | Round Way Iron Cocks .. ,, | .. | | 3 | 6 | 4 | 0 | 5 | 6 | 7 | 6 | 10 | 0 | 13 | 0 | 17 | 6 | 22 | 0 | 38 | 0 | 54 | 0 | 62 | 0 | 70 | 0 | 100 | 0 | 160 | 0 |
| 27 | Do. with Brass Plugs .. ,, | .. | | 5 | 0 | 6 | 6 | 9 | 0 | 13 | 0 | 19 | 0 | 28 | 0 | 36 | 0 | 42 | 0 | 60 | 0 | 85 | 0 | 105 | 0 | 120 | 0 | 180 | 0 | 280 | 0 |
| 28 | Cock Spanners, Wrought Iron,, | .. | | 1 | 0 | 1 | 4 | 1 | 8 | 2 | 0 | 2 | 4 | 3 | 0 | 3 | 6 | 4 | 0 | 4 | 9 | 6 | 0 | 7 | 6 | 9 | 0 | 12 | 0 | 14 | 0 |
| 29 | Do. Malleable Cast Iron .. ,, | .. | | 0 | 7 | 0 | 8 | 0 | 10 | 1 | 2 | 1 | 8 | 2 | 2 | 2 | 9 | 3 | 3 | 4 | 9 | 6 | 0 | 7 | 6 | 9 | 0 | 12 | 0 | 14 | 0 |
| 30 | Syphon Boxes, 1 Quart .. ,, | .. | | .. | | 11 | 0 | 12 | 0 | 13 | 0 | 14 | 0 | 15 | 0 | 15 | 6 | 16 | 0 | 18 | 0 | .. | | .. | | .. | | .. | | .. | |
| 31 | Do. 2 ,, .. ,, | .. | | .. | | .. | | 16 | 0 | 17 | 0 | 18 | 0 | 19 | 0 | 21 | 0 | 23 | 0 | 25 | 0 | 30 | 0 | 35 | 0 | 40 | 0 | .. | | .. | |
| 32 | Do. 3 ,, .. ,, | .. | | .. | | .. | | 20 | 0 | 22 | 0 | 24 | 0 | 25 | 0 | 26 | 6 | 28 | 0 | 32 | 0 | 35 | 0 | 40 | 0 | 45 | 0 | 50 | 0 | 56 | 0 |
| 33 | Do. 4 ,, .. ,, | .. | | .. | | .. | | 21 | 0 | 23 | 0 | 25 | 0 | 27 | 0 | 29 | 0 | 31 | 0 | 34 | 0 | 38 | 0 | 42 | 0 | 47 | 0 | 54 | 0 | 60 | 0 |
| 34 | Malleable Cast Round Elbows,, | .. | | .. | | 0 | 8 | 0 | 10 | 1 | 2 | 1 | 9 | 2 | 3 | 3 | 0 | 3 | 6 | 5 | 6 | 9 | 0 | 12 | 0 | 15 | 0 | 30 | 0 | 40 | 0 |
| 35 | Blast Furnace Tuyere Coils ,, | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**WATER WHEELS.**—Although one or other of the turbines for low falls which are referred to in the preceding pages have, to a large extent, superseded the water wheel, one type of which is represented by Fig. 1637; this most reliable form of motor is frequently preferable to any other where an ample volume of water can be relied upon during the periods when motive power is required.

Fig. 1637.

The data for ascertaining the power available and the relative efficiency of the different types of water wheels—as defined by those eminent authorities, M. Poncelet and M. Morin—will be found at page 84, and the following tables give the approximate powers developed by breast and over-shot wheels of different dimensions when working under given conditions of head and volume of water.

The arrangements for transmission of power necessarily vary, but the prices include the cost of a spur ring, which may be fixed on either side of the wheel and the pinion gearing with the spur ring, so that an estimate of the total cost of the installation is easily made by reference to the prices of shafting, gear, and accessories which are given in detail in Section VI. The prices of sluice gear and appliances for regulating it, which may or may not be required, are given separately.

Water wheels to fulfil conditions differing from those referred to in the lists, will be constructed if full information is given as to the power required, the quantity and fall of water available, and the restrictions (if any) in the diameter of wheel or weight of parts, the length of main shaft (wheel gudgeon) required and whether the wheel should be of the overshot, undershot, or breast type.

PRICES OF WATER WHEELS AND GEAR.

**Head of water 11 feet. Diameter of wheel 10 feet. Revolutions per minute 12½.**

| Horse Power. | Width of Wheel, feet. | Water required Cub. ft. per min. | Price of Wheel. | Price of Sluice Gear. | Approximate weight, tons. |
|---|---|---|---|---|---|
| 3½ | 2 | 264 | £53 | £5 | 2¼ |
| 6 | 3 | 453 | £65 | £7 | 3 |
| 8½ | 4 | 651 | £75 | £10 | 3¾ |
| 11¼ | 5 | 848 | £86 | £12 | 4¼ |
| 13¾ | 6 | 1046 | £98 | £15 | 5¼ |
| 19 | 8 | 1450 | £120 | £20 | 6½ |

PRICES OF WATER WHEELS AND GEAR—Continued.

**Head of water 11 feet. Diameter of wheel 12 feet. Revolutions per minute 10½.**

| | | | | | |
|---|---|---|---|---|---|
| 4 | 2 | 265 | £60 | £5 | 2¾ |
| 7¼ | 3 | 460 | £73 | £8 | 3¾ |
| 10½ | 4 | 660 | £85 | £10 | 4¾ |
| 13½ | 5 | 860 | £98 | £14 | 5½ |
| 16½ | 6 | 1058 | £100 | £16 | 6¼ |
| 22¾ | 8 | 1450 | £135 | £20 | 8¼ |

**Head of water 15 feet. Diameter of wheel 14 feet. Revolutions per minute 8¾.**

| | | | | | |
|---|---|---|---|---|---|
| 4½ | 2 | 268 | £72 | £6 | 3½ |
| 8¼ | 3 | 466 | £87 | £8 | 4½ |
| 12 | 4 | 670 | £100 | £12 | 5½ |
| 15½ | 5 | 868 | £115 | £14 | 6½ |
| 19¼ | 6 | 1070 | £130 | £16 | 7¾ |
| 26½ | 8 | 1445 | £160 | £22 | 9¾ |

**Head of water 21½ feet. Diameter of wheel 20 ft. Revolutions per minute 5½.**

| | | | | | |
|---|---|---|---|---|---|
| 7½ | 2 | 280 | £115 | £8 | 5¼ |
| 13¼ | 3 | 485 | £135 | £10 | 6¾ |
| 18¾ | 4 | 692 | £160 | £15 | 8½ |
| 24½ | 5 | 900 | £185 | £18 | 10 |
| 30 | 6 | 1105 | £205 | £20 | 11¾ |
| 40 | 8 | 1495 | £250 | £25 | 14¾ |

The cost of packing for shipment and delivery f.o.b. ranges from 3 to 5 per cent.

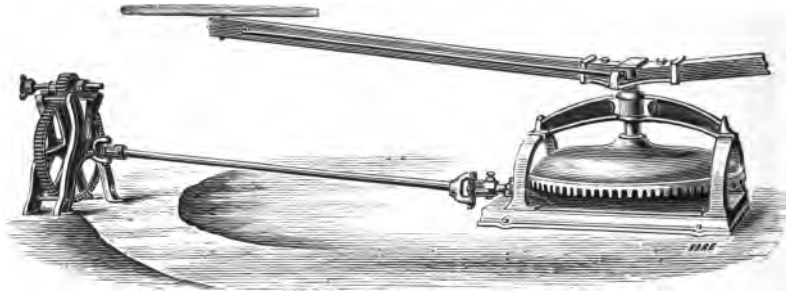


Fig. 1638.

**HORSE GEARS.**—The engraving, Fig. 1638, represents a one horse, pony or mule gear with separate intermediate motion for increasing the speed, and Fig. 1639 one with self contained intermediate motion and fitted for two horses or other animals. Those with poles for two or more animals are similar in construction but are proportionately stronger.

The speeds of the first motion, and without the intermediate motion, vary from about 6 revolutions in the smaller sizes to 8½ in the larger sizes for each revolution of the crown wheel made in one circuit of the horse path. The speeds obtained through the intermediate motion vary in each size; those with 42 inch driving wheel, which is illustrated by Fig. 1639, are 19, 26, 32 or 38 revolutions for one revolution of the crown wheel.

The subjoined prices include poles and whippletree or attachment for the yoke, and spring clutches easily adjustable for giving motion in either direction.

PRICES OF HORSE GEARS Fig. 1638.

| Diameter of crown wheel ..inches | 33 | 36 | 42 | 54 |
|---|---|---|---|---|
| Price for one horse gear .. .. | £8 5 0 | £9 2 6 | £10 10 0 | .. |
| Ditto two ,, .. .. | .. | .. | £11 10 0 | £14 17 6 |
| Ditto three ,, .. .. | .. | .. | .. | £16 7 6 |
| Ditto intermediate motion .. | £2 7 6 | £2 17 6 | £3 5 0 | £3 17 6 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

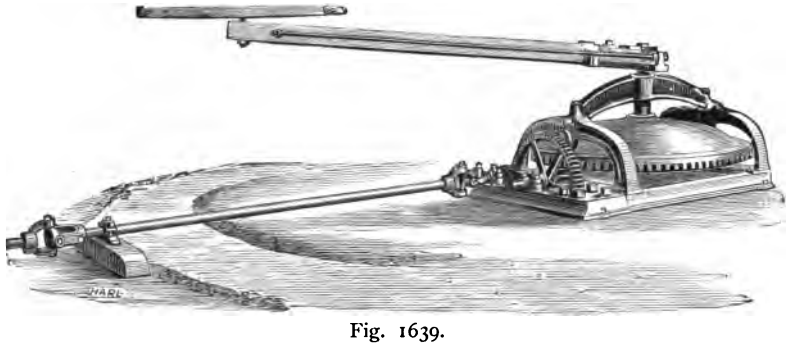


Fig. 1639.

PRICES OF GEARS WITH INTERMEDIATE MOTIONS, Fig. 1639.

| Diameter of crown wheel ..inches | 33 | 36 | 42 | 54 |
|---|---|---|---|---|
| Price for one horse gear .. .. | £10 10 0 | £11 10 0 | £13 0 0 | .. |
| Ditto two ,, .. .. | .. | £12 10 0 | £14 0 0 | £17 15 0 |
| Ditto three ,, .. .. | .. | .. | .. | £19 15 0 |
| Ditto four ,, .. .. | .. | .. | .. | £20 15 0 |

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

**EXTRA STRONG HORSE GEARS** for four horses or bullocks are sometimes required, in the Colonies and elsewhere, for continuous use. These are made to fix on a timber frame constructed by the purchaser, from drawings sent with the machine, and have speeds of 45½, 51, 58 or 66½ revolutions for each revolution of the crown wheel; the prices are as follows:—

| | |
|---|---|
| Four horse gear without intermediate motion .. .. .. | £27 10 0 |
| ,, ,, with ,, ,, .. .. .. | £31 0 0 |
| Extra pinion for second (bullock) speed .. .. .. | £2 10 0 |
| ,, for platform and driver's seat .. .. .. .. | £1 0 0 |
| ,, iron travelling wheels .. .. .. .. .. | £5 10 0 |

**WINDMILLS.**—Although the windmill requires little or no attention after it has been set to work and is used with advantage for pumping for water supply, for drainage, for driving farm machinery, &c., the velocity of the wind—especially in this country—is so variable and uncertain that it is frequently preferable to adopt some other form of motor which—whilst costing far more for maintenance and attention—is available whenever required.

The case is, however, very different in other countries where the wind pressure is fairly constant during certain seasons and high rates are paid for fuel and skilled labour. These conditions exist in the Australian Colonies, Canada, on the American Continent and elsewhere and the windmill is used with great advantage for pumping water, sawing, grinding corn, &c.

**WINDMILLS WITH TOWERS.**—The subjoined approximate prices for mills complete with towers in timber, or steel of lattice construction, and vertical shaft to ground line, afford a basis for estimating the cost of such mills, delivered and ready for re-erection. The height of the towers is 24 feet, and allowance must be made for any greater height required.

PRICES OF WINDMILLS WITH 24 FT. TOWERS.

| Horse power of mill .. .. | 1 | 2 | 3 | 4 | 5 | 7 |
|---|---|---|---|---|---|---|
| Diameter of sail .. feet | 14 | 18 | 20 | 24 | 28 | 30 |
| Price, with timber tower .. | £85 | £120 | £140 | £170 | £225 | £260 |
| ,, steel ,, .. | £95 | £135 | £165 | £200 | £250 | £285 |
| ,, of gear only .. .. | £50 | £70 | £85 | £110 | £160 | £190 |

The cost of packing for shipment and delivery f.o.b. is about 6 per cent.